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Fuel Problem Data

FOR some years the Society of Automotive Engineers has been studying through its committees and membership the various problems involved in the supply and utilization of suitable fuel for automotive apparatus, including passenger cars, motor trucks, tractors, motorboats, aircraft and stationary engines. At the January, 1919, meeting of the Society, comprehensive data were submitted and discussed on the subjects of sources of crude petroleum throughout the world, refining processes, methods of caburetion, principles of ignition and engine and vehicle design. The information collected and collated at this time was of great value.

The efforts of the Society were then directed energetically to the bringing about of exchange of views and information between the automotive and the petroleum industries. In addition to the Society, the following organizations cooperated in this movement: The American Petroleum Institute, the National Automobile Chamber of Commerce, the Motor & Accessory Manufacturers Association, the National Implement & Vehicle Association, the National Gas Engine Association, the National Association of Engine & Boat Manufacturers, the Manufacturers Aircraft Association and a number of Government Departments, including the Bureau of Standards and the Bureau of Mines. The Automotive Fuel Committee, composed of representatives of these associations and bodies, was formed. In addition, the S. A. E. Committee on the utilization of present fuels in the types of automotive engine currently produced, assumed activities which have been conducted faithfully and with very helpful results for more than a year. Various members of the Society have conducted exhaustive tests in their laboratories, having the hearty cooperation of the Bureau of Standards. A large amount of valuable information was presented to the members and through them to the public at meetings of the Society held in June, 1919, and of this year, at Ottawa Beach, Mich. The Society committee presented its report on the Utilization of Present Fuels in Present Engines and demonstrated automotive-type engine operation on heavy fuel, with complete runs using separate intake and exhaust manifolds for the purpose of indicating the running qualities without the inlet-heating arrangement recommended by the committee; with hot-surface combination intake manifold and with special cylinder-heads to show their effects, including that of turbulence. Two sessions of a duration of a half-day each were devoted to consideration of the whole fuel problem. One of the principal objects of the Society has been to bring about a situation wherein a universally adopted gasoline specification will be assured with available supply for the next several years, the oil industry advising the automotive industry far in advance of any apparent need of change in the specification. The cooperation of all the interests concerned has been of a broad and sympathetic character, and will undoubtedly have a great influence in the solution of the most serious phases of the fuel question as affecting the automotive industry. It is felt that if the same cooperation as now obtains between the fuel and the automotive industries, had been inaugurated three years ago, the problem with which the industries are now and have been struggling, would not have existed.

A pamphlet has been mailed to the membership which is designed to furnish in an exceedingly concise and readable form a summary and analysis of papers and discussions recently presented at meetings of the Society, these contributions of unusual value having naturally aroused much interest at this time when the quality, quantity and price of gasoline available in the future, particularly during the next several years, are in question. The purpose of the issuance of this special booklet by the Society is to disseminate in a clear manner the latest pertinent data of use to designers, producers and users of automobiles and other automotive apparatus, with regard to the economical and efficient use of such apparatus.

ABSTRACTS FROM RECENT PAPERS

THE USE OF HEAVY FUEL IN AUTOMOTIVE ENGINES

BY H. M. CRANE[1]

EMPHASIZING the necessity of persuading fuel manufacturers to improve the suitability of internal-combustion engine fuel by the mixture of other materials with petroleum distillates, and realizing that efficiency is also dependent upon improved engine design, the author then states that results easily obtainable in the simplest forms of automotive engine when using fuel volatile at fairly low temperatures, must be considered in working out a future automotive fuel policy.

The alternatives to this as they appear in the light of present knowledge are then stated, including design considerations. The principles that should be followed to obtain as good results as possible with heavy

[1]Member Automotive Fuel Committee.

fuel in the conventional type of engine are then described. These include considerations of valve-timing and fuel distribution. Valve-timing should assist correct distribution, especially at the lower engine speeds. Manifold design should include a steady up-grade from the carbureter to the inlet valves and the manifold should be compact on multi-cylinder engines; the best manifold shape must be worked out for each particular engine. The final requirement in utilizing heavy fuel of low volatility is heat, but for good distribution the less heat used the better, because high temperatures reduce volumetric efficiency. [Printed in this issue of THE JOURNAL.]

ENGINEERING POSSIBILITIES AS INDICATED BY THE PROGRESS OF SCIENCE

BY CHARLES F. KETTERING[2]

THE author views in perspective some facts from a purely scientific standpoint, and then shows their application to problems of the automotive industry. After reviewing the present facilities for measurement and the ability to make measurements of distances both infinitely small and large, as an aid toward a proper conception of the ultimate structure of matter, he applies this scientific knowledge in the direction of a solution of the fuel problem, which is a fundamental one because it involves the limitation of a natural resource.

From 1918 and 1919 statistics, the amount of gasoline produced was something like 20 to 25 per cent of the crude oil pumped; 8 to 10 per cent is kerosene and 50 per cent is gas and fuel oil and a residue carrying lubricating oil, paraffin and carbon. Kerosene demand and production are practically fixed quantities; gasoline demands are increasing. So, after utilizing 25 per cent for gasoline, the 8 to 10 per cent representing kerosene must be avoided and entry to the 50 per cent represented by the gas and fuel oil section must be made to get material with which to increase the amount of engine fuel. This is being done by the "cracking" process, by which about 33⅓ per cent of the total amount cracked becomes engine fuel, but this is an unsaturated compound and must be blended with normal fuel.

It would be possible to increase the engine fuel supply materially except that the lower-gravity fuels cause pounding in the engine, sometimes termed carbon knock and generally attributed to preignition but really due to a change in the fuel molecules. Carbon knock is entirely a function of the fuel. A carbon deposit acts as a blanket around the inside of the cylinder, so that the temperature rises and the molecules break down. This is overcome by lowering the engine compression, but this decreases efficiency.

It is possible to introduce certain compounds which will prevent the breaking down of the fuel molecules. The chemical and fuel industries should make and put those compounds into the fuel, because we can today transfer in our distillation 50 per cent of the crude oil right over into engine fuel, by using compounds which will prevent its molecular distortion, and get better results than those given by normal gasoline under normal conditions, at least until fuel can be produced by entirely different methods. To get fuel distribution we try to vaporize it by heat, and this is exactly the wrong thing chemically. Analysis of many carbon samples shows 90 per cent heavy hydrocarbons, 5 per cent of hydrogen-oxygen-carbon content and 4 or 5 per cent precipitated lampblack. That hydrogen-oxygen-carbon content is of an acid nature and cements the other constituents to the cylinder walls, but organic alkalies will act upon it and aniline will dissolve 95 per cent. It is possible today to run engines on fuel heavier than kerosene, and to run them indefinitely and guarantee that there will never be any carbon deposit. [Printed in the July, 1920, issue of THE JOURNAL.]

[2]General Motors Research Corporation, Dayton, Ohio.

CARBURETION AND DISTRIBUTION OF LOW-GRADE FUELS

BY O. H. ENSIGN[3]

CONTINUED lowering in the grade of fuel obtainable compels automotive engineers to produce engines that will utilize it with maximum economy. The manufacture of Pacific coast engine-distillate with an initial-distillation point of about 240 and an end-point of 480 deg. fahr. was abandoned by the principal oil companies early in 1920. Utilizing this fuel efficiently through its period of declining values forced advance solution of some fuel problems prior to a general lowering of grade of all automotive fuels. Keeping prominent certain essential features of economical design in connection with carburetion, the problems have been:

(1) An absolutely correct metering for all engine speeds and throttle positions so that the proportion of air to fuel meets correct engine design
(2) Adaptation to changed engine design, especially in connection with the manifold, or the entire mixture path; even fuel distribution to all cylinders being of higher importance than limiting manifold depression, and cylinders not pulling together having caused the largest loss in many designs

Realizing that the lower the grade of fuel the more difficult even distribution becomes and the more disastrous the results from poor distribution, the best way to accomplish maximum economy and power is stated as being the provision of a carbureter producing a mixture meeting theoretical operating conditions under throttle control with economy and flexibility, then to design manifolds that permit use of this mixture by insuring even distribution to all cylinders. A carbureter used for the past five years is illustrated and described in detail, with supplementary performance charts, and a fuel converter is likewise discussed. Manifold designs are next illustrated and commented upon, the conclusion being reached that in some cases a compromise between manifold depression and manifold turbulence on the one hand, and compression on the other, has made possible the use of extremely low-grade fuel and increased the power output. [Printed in the July, 1920, issue of THE JOURNAL.]

[3]President and engineer, Ensign Carbureter Co., Los Angeles, Cal.

SAVING FUEL WITH THE CARBURETER

BY W. E. LAY[4]

TWO series of tests were made in 1918; one to determine whether the mixture giving best economy and that giving maximum power is a constant quality for all conditions of speed and power output; the other to ascertain what effect changes in the temperature of the fuel-intake system has on the quality of the mixture which gives the maximum power and that which gives best economy. The standard United States ambulance four-cylinder engine was used for these tests, its carbureter having a primary air passage, a primary fuel-jet, an auxiliary air passage with an air-valve and a secondary fuel-jet, the manifold being cast in-

[4]Assistant professor of mechanical engineering in charge of automotive engineering, University of Michigan, Ann Arbor, Mich.

tegrally with the cylinder block and a curved riser conducting the fuel mixture from the carbureter to it. The testing methods and fuel consumption measurements are described. The results of the first series are shown on curves having mixture quality as abscissas and torque and thermal efficiency as ordinates, demonstrating that the mixture quality giving greatest power is different from that giving best economy, and that the mixture giving maximum economy becomes somewhat leaner as the power output is increased. Similar curves from the second series of tests, considering changes of temperature of the air entering the carbureter, warrant the conclusions that over the temperature range investigated an increase in the carbureter intake temperature means an increase in thermal efficiency and that the mixture giving best economy at a high temperature is a leaner mixture than that giving maximum economy at a lower temperature. These conclusions are then amplified, a further conclusion being that from 10 to 50 per cent more gasoline than is necessary may be used in operating. The ideal carbureter would supply a mixture giving best efficiency and automatically supply the necessary additional fuel only when operating conditions require this. [Printed in this issue of THE JOURNAL.]

ENGINE DESIGN FOR MAXIMUM POWER AND ECONOMY OF FUEL

BY C. A. NORMAN[5]

DESIGN factors are considered from the thermodynamic standpoint only, which excludes several factors affecting power and economy.

The problem of air heating includes a consideration of its influence on pressure, the consequent lowering of pressure being counteracted by improved carburetion and distribution and by more rapid and complete combustion; the effects of delayed combustion, with a study of the thermodynamic conditions and possible improvements; and the results obtainable from lean and rich fuel mixtures.

Fuel economy is difficult because its factors conflict with those of power. The benefit of the expansion of any elastic working medium to economy is emphasized. Charts from previous papers, showing the ratio of air to fuel by weight, are referred to and discussed, best economy being obtained with mixtures leaner than those giving maximum power. The effects of air heating on fuel economy, the reduction of efficiency through friction losses and the various results obtainable from supercharging, are then enumerated and discussed. [Printed in this issue of THE JOURNAL.]

SOME FACTORS INVOLVED IN FUEL UTILIZATION

BY P. S. TICE[6]

FROM a laboratory examination of the controlling relationships between carburetion and engine performance still in progress, the general conclusions so far reached include fuel metering characteristics, the physical structure of the charge, fuel combustion factors and details of engine design and manufacture.

In every throttle-controlled engine, the variation in fuel metering for best utilization is inversely functional with the relative loading and with the compression ratio, but the nature of the fuel leaves these general relationships undisturbed. The physical structure of the charge influences largely the net engine performance and the order of variation of the best metering with change in load. Perfect homogeneity in the charge is theoretically desirable but entails losses in performance. With the least perfectly formed charge that will operate an engine, increased outputs result from a more nearly uniform distribution of fuel in the charge, even though accompanied by a reduction in charge weight. Considering available petroleum fuels, those requiring the higher charge temperatures for maximum utilization also possess the ability to ignite at relatively lower temperatures when mixtures suitable for engine use are made.

It should be possible to operate an engine continuously at open throttle, without detonation, on a properly constructed charge of any petroleum fuel proposed to date, with a compression ratio resulting in gage pressures including 75 lb. per sq. in., but an analysis of the failure to do this shows that preignition is the direct result of local overheating in the charge. Augmenting turbulence decreases local overheating and so appreciable inequalities of combustion-chamber surfaces must exist, and high piston-head and exhaust-valve temperatures contribute to a condition favoring detonation. Piston design, exhaust-valve and spark-plug electrode cooling are then considered, mention being made also of piston gas-tightness as being very important. Net engine performance is the square root of the brake mean effective pressure divided by the brake specific consumption, combining the cost of unit power and the amount of power obtained. Its value attains a maximum with mixtures only slightly richer than those resulting in the true minimum specific consumption. With manual throttle control, steady and consistent operation obtains throughout the throttling range when realizing the minimum possible specific fuel consumption but, so far, possible maximum utilizations cannot be realized in operation under governor control. These considerations are illustrated by charts, showing curves resulting from the experiments made. [Printed in this issue of THE JOURNAL.]

THE FUELIZER

BY J. G. VINCENT[7]

IN connection with his paper Adapting Engines to the Use of Available Fuels,[8] the author states that engine fuel must be vaporized completely under part-throttle conditions, but that this need not necessarily be done under full-throttle conditions previously to introducing the fuel into the cylinders. He then describes a system of supplying the necessary heat under part throttle and automatically cutting it off under wide-open throttle conditions by a device designated as a fuelizer. The principle of this device is to take advantage of the difference in pressure existing on either side of the carbureter butterfly-valve, and cause a small amount of the combustible mixture to pass through a passage which is parallel with the main carbureter passage, burn this mixture in a suitable burner and then allow the burnt gases to mix with the incoming main supply to the engine above the throttle. It is evident that this general scheme is at its maximum efficiency at low-throttle and light-load; an intense heat is generated very promptly under these conditions, which are obtained when starting and when idling. As the throttle is gradually opened there is less and less tendency for the mixture to take the by-pass through the burner and consequently the burner gradually goes out of action so that, under wide-open throt-

[5]Professor of machine design, Ohio State University, Columbus, Ohio.
[6]Engineer in charge of carbureter division, Stewart-Warner Speedometer Corporation, Chicago.
[7]Vice-president of engineering, Packard Motor Car Co., Detroit.
[8]See THE JOURNAL, November, 1919, p. 347.

tle conditions, when it is desired to maintain the volumetric efficiency of the engine as high as is possible, but very little mixture passes through this "shunt" passage and a negligible amount of heat is produced in the burner.

In actual operation, when the engine is idling, combustion takes place in the burner silently and continuously and a bluish-green flame completely fills the combustion chamber. This flame diminishes in intensity as the throttle is opened and the depression in the main intake header is thereby decreased, the general result being that for ordinary driving up to 25 m.p.h. a mixture temperature of 150 to 180 deg. fahr. is maintained, giving excellent distribution, very good acceleration, decided reduction of spark-plug fouling and very materially diminished dilution of the lubricant in the crankcase. At higher speeds and wider throttle-opening the influence of the fuelizer gradually decreases until at wide-open throttle it is practically out of action, which is to be desired.

CONTROLLING AND ATOMIZING FUEL BY VARIABLE ENGINE PRESSURES

BY JOHN G. WILLET[9]

THE tremendous demand made by the automotive upon the oil industry has forced the refiners to raise the end-point of gasoline from 300 deg. fahr. in 1918 to 437 in 1919. The application of hot-spots to intake manifolds has helped to assimilate the heavy fuels by boiling the heavy ends into a vapor, but with all these improvements crankcase dilution, hard starting in cold weather, poor acceleration, loading of the intake manifold at low speed and an inability of the existing types of carbureter to furnish the proper mixture of air and fuel to meet the variable engine loads, are difficulties that still exist. Crankcase dilution and intake-pipe loading clearly indicate imperfect atomization; the majority of present carbureters employ two or more spray-jets to improve atomization. In 1907 the author designed a fourteen-jet carbureter that was used successfully on racing motor boats. Results obtained by mixing kerosene with high-test gasoline demonstrated that more power can be secured with the heavier fuel, provided the carbureter can atomize it.

After a survey of the considerations involved in controlling the fuel and a discussion of horizontal versus vertical carbureters, illustrations of a special-type carbureter designed by the author are presented and a detailed description given. Its qualifications were designed to cover

(1) A jet that will thoroughly atomize heavy fuels under all speeds and conditions, including low temperature
(2) A vaporizing device that would supply enough heat at low throttle and could be adjusted for various grades of fuel, or for weather conditions
(3) Means for controlling the fuel supply so that mixtures of various qualities will be delivered to meet the varying loads of the engine

An auxiliary air-valve is employed (*a*) to use a small-diameter venturi throat to keep a high velocity at idling speed and extend the blending to as large an area as possible, and the auxiliary air is blended at high velocity and distributed over an extended surface, as the circumference of the top of the venturi tubes makes this possible; (*b*) the air-valve carries a metering-pin which corrects any error in pressure regulation. The operation is further described and the action of the vaporizer is discussed, followed by statements of the advantages gained with the pressure type of jet. The conclusion reached is that they indicate that some time the less-volatile fuels can be used and that probably better economy and more power can be secured, due to the higher percentage of heat units contained in the heavier fuels. [Printed in the July, 1920, issue of THE JOURNAL.]

[9]Sterling Oil Corporation, Buffalo.

KEROSENE AS A TRACTOR FUEL

BY JOHN A. SECOR[10]

KEROSENE has advanced to the front rank as a fuel for the farm tractor within a decade. A heavily preponderating majority of tractors burn kerosene. The history of early oil engines is reviewed and some comparative costs of kerosene and gasoline fuel for tractors, obtained from tests made in January, 1920, are given. Kerosene tractor-engine development is then discussed. The conditions required for complete combustion are the same in principle for both kerosene and gasoline, but in actual practice a wider latitude in providing ideal conditions is permissible for gasoline than for kerosene.

The four classes of commercial liquid fuels usable in internal-combustion engines are the alcohols, the gasolines, the common kerosenes and the low-cost heavy-oil fuels. The alcohols rank lowest in heating value per pound of combustible. Under existing economic conditions neither alcohol nor the fuel oils require consideration as available fuels for the tractor. The problem of producing an acceptable oil-burning tractor has been solved. The oil engine is no longer inferior to the gasoline engine, but the oil-burning tractor of the future must burn oil without waste. In some 1919 tests the average fuel consumption of seventeen kerosene tractors was 0.963 lb. of kerosene per b.-hp.-hr. and the average of four gasoline tractors was 0.951 lb. of gasoline. Six tractors used more than 1 lb. of fuel per b.-hp.-hr. But in the 1920 tests, twenty-eight tractors showed an average consumption of 0.889 lb. per b.-hp.-hr. The 1912 record performance of an oil-burning tractor was 0.700 lb. but the 1920 performance at Columbus was 0.606 lb. of kerosene per b.-hp.-hr. Private tests of tractors of the same type have shown results as low as 0.550 lb. of kerosene per b.-hp.-hr.

The kerosene tractor should consume less fuel than the gasoline tractor because of the greater heating value per gallon of kerosene. The problem of using oil for fuel in the throttle-governed engine is complicated because the controlling factors become variables whenever there is a change in power or in engine speed. After analysis of the chemical merits of kerosene and gasoline and their respective boiling points, it is stated that because kerosene is heavier, is comparatively non-volatile and has a higher viscosity coefficient than gasoline, engineering authorities have assumed that difficulties encountered in burning kerosene at higher loads are almost wholly attributable to the heterogeneous nature of the compounds composing kerosene.

Regarding ignitibility of fuel mixtures, rate of flame propagation, preignition and cracking in throttle-governed engines, experience shows that internal temperature conditions suitable or permissible for gasoline are impracticable for kerosene. The effects of compression and temperature on the fuel-to-air ratio have been recognized for many years. The quality, quantity, compression and temperature of fuel mixtures are controlling factors in the operation of all gas engines, but in throttle-governed oil engines the regulation of all these factors in coordination demands greater consideration than is necessary for ordinary gasoline engines. These considerations are then elaborated.

Water is an efficient and suitable medium for regu-

[10]Consulting engineer, Advance Rumely Co., La Porte, Ind.

lating heat conditions in a throttle-governed oil engine. Water can be used internally as well as in the water-jacket. This is amplified in some detail. The art of burning kerosene is comprehended in that all controlling factors of combustion, including the proportions of the fuel mixture and its temperature at the time of ignition and during the working stroke, must always be kept in physical correlation with the density of the air. When the compression is a variable, the other controlling factors must also be varied in coordination with the compression, so as to maintain efficient working relations between compressions, mixture ratios and temperatures during varying load. Thorough mechanical admixture of fuel, air and water is essential in using kerosene. [Printed in this issue of THE JOURNAL.]

INTAKE MANIFOLD TEMPERATURES AND FUEL ECONOMY

BY W. S. JAMES,[11] H. C. DICKINSON[12] AND S. W. SPARROW[13]

SUPPLEMENTING a "more miles per gallon" movement in 1919, a series of experiments outlined by the S. A. E. Committee on Utilization of Present Fuels was undertaken by the Bureau of Standards, in May, 1920, which included measurements of engine performance under conditions of both steady running and rapid acceleration with different temperatures of the intake charge secured by supplying heated air to the carbureter from a hot-air stove, by maintaining a uniformly heated intake manifold and by using a hot-spot manifold, fuel economy being determined for both part and full-throttle operation. A typical six-cylinder engine was used, having a two-port intake manifold with a minimum length of passage within the cylinder block, an exhaust manifold conveniently located for installing special exhaust openings, rather high peak-load speed and conventional general design. The carbureter was selected with the requirements in view of securing definite and measurable conditions of the intake charge and accurate measurements of the behavior of the charge as indicated by fuel consumption in pounds per brake-horsepower hour. Provision was made for an unusually complete series of measurements. These are described, the most unique being the construction of the tee portion of the manifold of Pyrex glass. Motion pictures of the manifold were taken during operation, but in only one run were the walls completely dry, and a surprising amount of directly applied heat was required to accomplish this.

The main series of runs was made with the exhaust-jacket manifold, in an attempt to determine how best to obtain low fuel consumption and rapid acceleration and how this result was influenced by changes in the amount of heat furnished the intake charge or in the method of supplying this heat. The fuel consumption tests were made at both full and half load at speeds of 650 and 1200 r.p.m. Full details of the tests are then stated, the results are presented in charts, and these are discussed. The results obtained are then summarized as follows:

(1) At constant speed, mixture ratio and power output fuel consumption in pounds of fuel per brake-horsepower-hour are independent of the temperatures and methods of heating the intake charge within the range tested

(2) The rate at which an engine will accelerate with a given mixture ratio, or carbureter setting, is markedly affected by the amount of heat supplied to the charge and its method of application. Within the limits of this work, the greater the amount of heat supplied to the charge and the higher its temperature at the intake port, the more rapidly the engine would accelerate.

[Printed in this issue of THE JOURNAL]

DISCUSSION AT THE SUMMER MEETING

THE fuel sessions at Ottawa Beach were very well attended and a great many experiences and theories were recorded by members which will be of the greatest value to the automotive industry. An analysis of the discussion and quotations from statements of members of the Society upon various phases of the fuel subject follow:

In speaking of the experiments that had been conducted by the Bureau of Standards to check the report of the Society Fuel Committee, Dr. H. C. Dickinson stated that "the results obtained in the series of measurements have almost entirely verified the predictions in the report and have gone considerably farther than the report in establishing numerical values representing the optimum temperature with which the mixture should be supplied at different speeds and loads, and in demonstrating to a certain extent the variation in economy which is produced by variations from this typical temperature. They have, I believe, not demonstrated so markedly the advantages of the typical hot-spot over the method of the heated manifold." In addition he stated that the experiments had shown "that not only good operating conditions but good acceleration can be obtained with an economical mixture if the temperature is maintained at about the right point." There was only one major discrepancy in the results determined by the Bureau of Standards and the recommendations in the Fuel Committee report. Dr. Dickinson said: "The report sketches the spots at which heat should be applied in the hot-spot manifold. It represents an excessive amount of heat supply at the upper portion of the tee and the tee manifold. That proves not to be the place where, under most operating conditions, the heat is really needed. The fuel comes up the lead, strikes the transverse section of the cross tube and does not stay on that surface to any extent. Instead at almost all throttle openings and almost all speeds there is a very considerable building up of a pool of liquid near the lower ends of the tee bend."

The need for economical fuel consumption was brought out very strongly, and stress was laid on the necessity of increasing the economy of cars not equipped with efficient carbureters and manifold. It is felt that if all of the cars in operation were run efficiently, a very large step would be taken in the matter of gasoline economy, this applying particularly to low-priced cars, of which there are very large numbers in use.

THE HOT-SPOT MANIFOLD

The need for hot-spot manifolds was brought out very clearly in the evidence that was offered, showing that

[11] Associate physicist, Bureau of Standards, Washington.
[12] Physicist in charge of powerplants research, Bureau of Standards, Washington.
[13] Associate mechanical engineer, Bureau of Standards, Washington.

manifolds do not actually operate in a dry condition. H. L. Horning, chairman of the S. A. E. Fuel Committee, stated with reference to the motion pictures which had been taken by the Bureau of Standards of its experiments with a glass manifold, that these showed "large quantities of gasoline traveling along the intake manifold when we all think it is dry. I think Dr. Dickinson's assistants will show that even at 500 deg. fahr. there is still some moisture in the manifold." Dr. Dickinson, in summarizing the results of the Bureau of Standards' tests, remarked that "At all ordinary temperatures a very large proportion of the liquid fuel goes through the manifold in the form of liquid. This liquid, contrary to our usual belief, collects very quickly on the surfaces of the manifold. In other words, a manifold in distributing fuel acts as a surface over which the liquid flows; that is, a very large percentage of the fuel, particularly under cold operating conditions, is distributed by surface flow on the walls of the manifold."

The hot-spot type of manifold was discussed at length during the meeting. H. L. Horning said, "The hot-spot method of manifolding was selected by the Fuel Committee because it seemed to be the only common ground on which we could get anywhere. The committee does not believe that it is a perfect system, but that it is so much better than the average system that it is worthy of anyone's investigation." He felt that the best summation of the research of his committee could be given in the following words: "There are a few spots in the manifold where the fuel separates out, and if you make that hot enough, you will get along. That is all it amounts to." He called attention to the one limitation of the hot-spot method of utilizing present-day fuels by saying, "You will find that when the engine is running at low speed, the end-point of the fuel, that is, the point at which it will boil out, is higher than the temperature of the exhaust. This is a very important fact and shows somewhat the limitation of the hot-spot method."

D. L. Arnold of the International Harvester Corporation described the results which he had obtained with a type of manifold where heat is applied all the way around the manifold. "We find that we do not heat the total air in the charge sufficiently to lower the maximum horsepower appreciably. Our theory of the engine delivering its maximum horsepower, although it is supplied with the total heat, is: that the fuel rides the wall, thereby insulating from the heat the air in the center of the stream. The air in the center of the stream is not heated sufficiently to reduce the volumetric efficiency materially. To get the greatest efficiency, it is my impression that we must put the fuel into the cylinder in liquid form. After it is locked in there and by the time ignition occurs, the fuel should be in a vapor state and should expand in such a manner that the volume liberated after ignition keeps pace with the piston travel in order to give a good smooth car."

A. W. Scarratt of the Minneapolis Steel & Machinery Co. acquainted the members with some experiments he had made with the manifold shown on page 123. He explained that "the diagram represents the four cylinders with the exhaust manifold on one side coming through between the cylinder blocks and joining the intake manifold on the opposite side. The exhaust, in coming across, passes through a jacketed portion of the intake manifold, *a*, completely enveloping a Y-shaped section of it, and then passes out. The main inlet to the manifold is in a vertical position, and an ordinary plain-tube carbureter is used. The gases, in being drawn up the main stand-pipe, pass through practically a nozzle, the area at the outlet of which is considerably smaller than the cross-sectional area of the carbureter. At *b* this is brought rather close to an umbrella, which is the most intensely heated part of the vaporizing chamber and the fins of which hang down and obstruct the passage of wet fuel directly into the intake manifold. This has a deflecting effect upon the heavy particles of fuel, tending to throw them down on the bottom side of the main intake plate on either side, and it is an actual fact that by providing an additional dam at points *c* we gather a small amount of liquid fuel in the two pockets. In this way we prevent the raw fuel from going over. The two pockets are out of the airstream entirely and are heated in each case, thus acting as a distillation pot for the raw fuel. We have run some tests with an engine equipped this way, which show that we can operate at full load and get a fuel economy of 0.589 lb. per hp.-hr. We can easily get down to 0.600 on kerosene. The most gratifying thing about it is that we seem to have attained just the desirable temperatures at full load, and yet when idling the intake manifold temperatures rise approximately 35 to 40 deg., which gives a good idling mixture. We have idled this engine at a slower speed than we have ever been able to idle a four-cylinder engine before."

R. W. A. Brewer called attention to the fact that the kind of metal from which the manifold is cast has some effect upon the hot-spot application. He said, "An important feature is that the Fuel Committee has made no mention of the metal to which the figures refer. It is evidently cast iron. There is some slight difficulty, perhaps, in arranging the various areas which are necessary to make a heated manifold conform to the figures and the curves given in this report when we are using various types of metal, including aluminum. We know that there are many designs and constructions of manifold in which aluminum forms an important part. There is also the immediate probability of metals of greater conductivity, such as copper, being used partially in the construction of manifolds."

Prof. W. E. Lay said that his experiments at the University of Michigan had shown that "if you operate with a higher intake manifold temperature, you will get higher thermal efficiency. You also run at a leaner mixture to get the best efficiency. These two conditions should not be confused. Adjustment should be made on the carbureter so that they can be handled separately, never sacrificing economy to get increased power or acceleration."

F. C. Mock referred to the question of temperature in the intake manifold and called attention to the fact that the intake and exhaust-manifold temperatures could be read while the test engine was in operation at the Summer Meeting of the Society, proving that "Although the temperature increases with the speed, the intake-manifold temperature in a hot-spot manifold does not change more than 5 per cent of the absolute temperature of the whole range of the engine speed. In this particular engine, there was a tendency of the intake temperature to rise as the throttle was closed at any given engine speed."

Turbulence and Detonation

Probably the two most important subjects discussed at the Fuel Sessions were those of turbulence and detonation. H. L. Horning particularly emphasized the need for preserving turbulence of the mixture in the engine. He said in part, "We do not produce turbulence, but we really preserve it. All engines have turbulence, but in

most of them it is dampened out before it does any good." He warned against the design of combustion chambers with opposite faces parallel, since in this case there is a tendency to straighten out the turbulent currents in the gas which are produced by passage around the throttle, the intake valves and the manifold bends. Promotion of turbulence enhances flame propagation, which is essential if reasonably high compressions are to be maintained without detonation, according to Mr. Horning's theory.

Dr. Dickinson said: "Turbulence and proper forming of the intake valve and its surroundings have an important bearing on distribution and the rate of burning of the fuel." In another part of the discussion Mr. Horning stated that "If you have not turbulence to keep the individual or unit particles from taking fire from the exhaust valve, you will have detonation; so it is a very bad policy to have a spark-plug located so that there is a chance of running the mixture in at the other end of the chamber over a very hot spot."

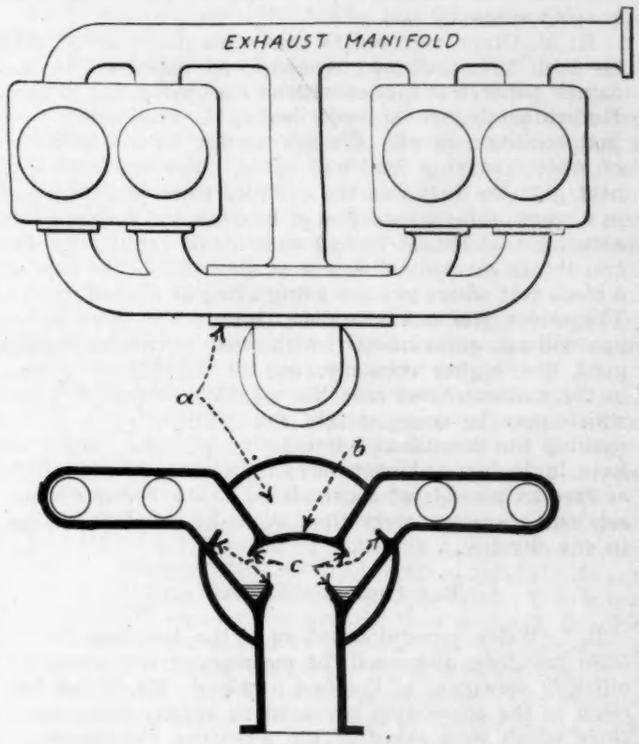
It is very generally known that, since the advent of the present high-endpoint fuels, a peculiar type of knock has become common in most engines. This knock is somewhat like that resulting from an advanced spark. Thomas Midgley, Jr., felt convinced that this knock is not mechanically harmful to the engine, but just annoying. He described some research work that he had done with C. F. Kettering by saying, "In the first place, we had observed before, through a little window in the cylinder-head, that when an engine knocked the flame in the window was yellow. When it did not knock, the flame was blue, running on the same fuel. We put an explosive mixture in a glass tube, fired it at one end, and showed that we got detonation by breaking the tube. We observed the flame; it started out blue, and as it progressed through the tube it became yellow. We analyzed this yellow flame with a spectroscope and found that when the engine knocked we had blue carbon bands. When it did not knock they were absent. When the engine knocks, you can see the fine carbon coming out of the exhaust pipe, and when it does not knock the same exhaust flame will be clear.

"Knocking fuel is a fuel in which the ratio of the hydrogen is very high compared to the number of bonds in the molecule. The hydrogen is carrying the detonation forward, and the bonds are trying to hold it back. The ratio between them is a measure of the tendency of the fuel to knock.

"We examined our data and found a little table of fuels in the order in which they knocked. As we figured them out, we put them down with a sort of baseball percentage. The ethers were put at the head of the list as knocking at 1000, the paraffins about 960, the olefines about 860, the naphthenes about 855, the alcohols 600, and the aromatics 540.

Mr. Horning reiterated that the position of the spark-plug has a considerable influence on detonation and recommended that it be located at "the best place at which you can start combustion, burn the mixture quickly and yet not arrive at the high rate of flame propagation known as detonation. Combustion will spread fastest in the center of a mixture that is traveling fast because of its turbulent nature, and never get to the point where it can detonate." He advised against placing spark-plugs on the cylinder center in L-head engines, since the mixture would first be subjected to the heat of the exhaust valve, cylinder and piston before reaching the plug and might detonate as a result.

Prof. C. A. Norman, during the discussion of his paper,



THE HOT-SPOT MANIFOLD DESCRIBED BY A. W. SCARRATT

emphasized the necessity of speeding up the combustion in the cylinder to reduce fuel consumption without a corresponding reduction in power. He referred to the mathematical calculations he had made in his paper to prove this statement.

TEST BLOCK AND SERVICE CONDITIONS

Many of the members emphasized the necessity of not confusing results obtained on the test stand or dynamometer with those made in actual service. R. W. A. Brewer stated that he had "found that in conducting experiments on heated manifolds one is very likely to be led astray by deductions made upon the block, because running conditions upon the road bring many other factors into account which might not be foreseen and considered in block tests. There are certain points in the report which apparently overlook that influence of road conditions. One is the cooling of the apparatus after the hot-spot feature has been passed. In the work in which I have been engaged I pay particular attention to the after-cooling, because I attach great importance to cooling the mixture after it has been initially heated, provided any relation can be maintained between the temperatures in the induction system consistent with the drop of temperature between the various points of the system. If that is done by proper design, the mixture can be maintained in the state in which it has been produced in the heating element. Another point that may lead one astray is that when idling the temperature is greater than at full load. One must bear in mind the conditions of the particular job. Undoubtedly, in some engines, there is much conduction of heat from the water-jacket down the limbs of the pipe, which perhaps gives a false or misleading reading of the temperature in the pipe itself. This temperature may occur at the location of the thermometer or other apparatus measuring temperature, but it may

not be a true measure of the temperature existing in the heating element."

H. M. Crane referred to this same discrepancy when he said, "The full-load economy, as explained in Mr. James' paper, was higher without the application of heat. Unfortunately, we are not dealing in road work with that condition at all. We are dealing with a condition of widely varying load and speed. The application of heat gets the fuel into the cylinder more promptly and in a more uniform condition of mixture and accomplishes economy that cannot be had with a cold condition. The two things are not consistent at all. One is the case of a block test where you are going along at a steady speed. The colder you can introduce the air the more power you will get, and evidently, with other conditions equally good, the higher economy, due to the higher power. in the road-condition case the manifold is full of liquid which may be dragged into the cylinder suddenly by opening the throttle and defeat your purpose. What we have to do for road work is to try to keep the manifold as free as possible of accumulated liquid, because it upsets our operation every time we make a sudden change in the throttle.

The Oilman's Viewpoint

R. L. Welch, general secretary of the American Petroleum Institute, addressed the members, giving them the oilman's viewpoint of the fuel problem. Mr. Welch had come to the convention prepared to answer three questions which were asked of the American Petroleum Institute by the Society. These questions, with excerpts from Mr. Welch's answers, follow:

Question: With predicted production of automotive apparatus for the next three years, can you state that the gasoline end-point will not exceed 440 deg. fahr. on or before Jan. 1, 1922, or can you tell whether it is possible to hold to this limit until Jan. 1, 1923? With this specification will it be possible to keep 140 deg. fahr. initial boiling point?

Answer: No reasonably well-informed man likes to make predictions about the oil business. At the same time, the logic of the situation is such that if I were an automotive engineer, I would plan to use and conserve the present-day fuels. The only fuels possibly available aside from the present-day engine fuels are kerosene and perhaps a distillate similar to the fuel which is used in Diesel engines, that is something approximating gas oil. Gas oil and kerosene are tending to become as scarce as gasoline. At the present time many gas companies in the United States are in distress for gas oil. It has more than doubled in price in a comparatively short time. The demand for kerosene has been so great that the tank-wagon market price of kerosene throughout the country is approximating two-thirds of the tank-wagon market price of gasoline. A short time ago it was about one-half. This increasing demand for these heavier distillates is a demand which will apparently continue and which must be met, because we must never forget that the kerosene lamp is a long ways from being supplanted, and that the demand for gas oil will continue to be very great.

The price of kerosene and gas oil is rising more rapidly than the price of gasoline. With the great demand for these two products I do not see where the kerosene is going to come from to enlarge the fuel supply; and, if the kerosene or gas oil is available, it seems obvious that by efficient refining methods it will be cracked into gasoline approximating in its boiling points the ordinary grades of fuel in use throughout the country. If you design your engines to use these two heavier fuels, it looks as though the oil industry were going to beat you to it by cracking and making gasoline out of both of them.

Question: With the stated production of automotive apparatus, does it appear to you that it will be impossible to furnish fuel for the growing use of the apparatus?

Answer: I believe that it will be possible to furnish that fuel, provided we have the cooperation of everybody who has a close relationship to the problem. I believe that it will not be solved unless we have that cooperation. If the Government will cooperate with the oil industry, the same courage and the same business ability which have characterized the automotive industry and the oil business will get the oil, in my judgment.

Question: Will the price of crude oil and of petroleum products generally take a course independent of general commodity prices, or will the price of these follow the rise and decline of commodity prices and labor?

Answer: I do not know.

Mr. Welch gave some statistics in an interesting manner that acquainted his listeners with the present rate of consumption of gasoline. He said in part: "In 1911 the oil industry had to supply gasoline for only 700,000 automobiles. From the supply there were 314 bbl. of crude oil available for each automobile. Last year there were only 50 bbl. of crude oil available from domestic production for each automobile in use in the United States. There is the story, from 314 bbl. in 1911 to 50 bbl. in 1919. If you produce the cars which it is predicted you will produce, and if production of crude oil does not increase any more rapidly than it has in the past, there will be available per car 40 bbl. of crude oil this year, 1920. In 1922, if the prediction of your statistics that there will be nearly 12,000,000 cars registered is correct, there will be provided in this country 35 bbl. of crude oil per car, if it does not increase more rapidly than it has in the past."

Mr. Welch called attention to the difference between production and consumption in the following words: "I just call your attention to the fact that in 1919 we consumed 375,000,000 bbl. of crude oil. Since the first of August and down to the first of March, we have been consuming at the rate of 436,000,000 bbl. per annum, and we have been producing at the rate of 402,000,000 bbl. per annum, meaning an excess consumption over production of 34,000,000 bbl."

The speaker stated that the remedy for the present fuel shortage lies in the hands of the following people: "First, the Government must cooperate with the oil industry and with you gentlemen at home and abroad if the gasoline problem is to be solved. Second, the greatest possible efficiency must be attained by the automotive industry and by the consumer from internal-combustion engine fuel. Third, the oil industry must be more efficient and get more gasoline from each barrel of crude." Further referring to his second remedy, the efficiency of the products of the automotive industry, Mr. Welch said that it was his personal opinion that there is need to curb the present demand of the American public for 70 or 80 hp. engines in motor cars which operate generally at 20 m.p.h.

During the discussion of Mr. Welch's remarks, many of the substitutes for gasoline were considered. He said, regarding shale oil: "There is, as yet, no practical commercial method, as I understand it, whereby gasoline and crude oil can be obtained from shale. There are vast quantities of oil in shale." Referring to casinghead gas, Mr. Welch said he thought that "the casinghead gasoline will be increasingly used. We must use it. It is a good product, and the only problems in connection with it are, first, safety in handling it; if it is properly blended it is

as safe as ordinary gasoline; and, second, in a good many instances casinghead gasoline improperly blended with kerosene or other of the heavier fuels is found. Therefore, the problem of the user or the engine designer is a very difficult one, and, of course, when there is a tremendous strain upon gasoline consumption, as is the case now, the tendency on the part of many dealers is to take a car-load of casinghead gasoline and mix it with something which is too heavy, or to improperly blend it." The last sentence of these remarks on casinghead gas raised the question regarding the sale of poor gasoline at many of the smaller stations, and Mr. Welch thought that "in the long run the consumer will determine that question. His own discrimination will be sufficient. He will go to reliable and reputable concerns and get reliable gasoline. That is the solution."

There was considerable discussion regarding the increase in the price of gasoline, and Mr. Welch made the following remarks on this phase of the subject: "The change in prices, which recently occurred, occurred by reason of the change in the relationship of production to consumption. . . . It is not the producer who names the price. The fellow who determines the prices in this country is the consumer. . . . There never was a time in the history of the oil business when there was so much competition as there is today, and there is more competition in the oil business, I believe, than there is in the automotive business. . . . Just to give you a few figures: In 1911 the Standard group refined 80 per cent of the petroleum refined in the United States. In 1915 the Standard group refined 60 per cent of the petroleum produced in the United States. In 1919 the Standard group refined only 49 per cent of the crude oil refined in the United States. Is that monopoly? These are the official figures taken from Government reports. In 1919, for the first time in the history of the oil business, the independents refined more crude oil than all the affiliated Standard companies." Mr. Welch quoted as further evidence of the cause for increase in gasoline costs the following sentences from a memorandum which was submitted by the oil industry to the Federal Trade Commission: "The low reserve stocks of the country have been and are being dangerously depleted, and further advances will probably ensue unless production increases or consumption decreases, because the latest figures demonstrate conclusively that an equilibrium between supply and demand has not been reached. Furthermore, the recent advances in crude have not as yet been fully reflected in the prices of refined products." Mr. Welch was asked by one of the members who it is that settles the price of gasoline, or, in other words, how it is arrived at. He replied, "No one person and no single group of persons settles the price. Nobody settles the price, except the producer, the consumer and the law of supply and demand." Mr. Welch was asked why gasoline prices advance or decline at about the same time throughout the country, and why those prices are reasonably uniform. He replied, "The recent advances in the price of gasoline have been a mere reflection, and not a complete reflection, of the recent advances in crude. As to the advances being more or less uniform, here again there is a mere reflection of a national situation because crudes throughout the nation have advanced. So far as uniformity is concerned, can you buy coal, clothes, shoes, or automobiles, or any other articles in common use at prices which are substantially different respectively throughout the United States, freight and other costs considered? By the way, who is it who determines what the uniform scale of automobile prices throughout the United States shall be? No one; the prices are determined by competition."

The exportation of gasoline has had very little effect upon the situation, according to Mr. Welch. He said, "Up to two or three years ago, we were practically balancing our exports and imports, broadly speaking, not in terms of specific commodities but of totals. We shall, however, have to import vast quantities of oil."

When questioned as to the tendency of the oil companies to use cracking processes, Mr. Welch said, "Some of the oil companies have cracking plants that are idle because they cannot get material to crack. On the other hand, companies which have crude available are putting in cracking processes, and undoubtedly more gasoline will be cracked in the future than in the past."

When asked about available storage stocks of gasoline, Mr. Welch replied, "Except where there is a slack demand, I do not consider the fluctuations in the stocks of gasoline particularly important. Where the demand is slack, there may be a temporary recession in price in various localities, not justified by general conditions, because of the fact that gasoline is a liquid commodity and the storage facilities are therefore limited. It cannot be piled up like so many cords of wood. Where consumption is equal to or greater than demand, the fluctuations in the stocks of gasoline are not particularly significant. These stocks are mere working stocks. It is the supply of crude which is effective. The available storage of gasoline is very small in comparison with the demand. If we relied upon our storage stocks of gasoline, even when they are largest, we would be living a mere hand-to-mouth existence."

Use of Casinghead Gasoline

F. C. Mock in a written discussion submitted later said that "In many parts of this country fuel is being sold which contains a noticeable percentage of casinghead or very high test gasoline so volatile that it boils at relatively low temperatures, for instance, between 84 and 120 deg. fahr. The hood temperature of practically every car in warm weather is higher than this, and such gasoline naturally boils away when it gets under the hood, not only making trouble by the boiling bubbles of vapor interfering with the feed of gasoline to the carbureter, but also resulting in a lower mileage per gallon, because this part of the gasoline boils away and is wasted before it ever reaches the carbureter jet. In the winter time this light casinghead component would be of great value, but in the summer time it is of use to the people selling the fuel but not to the man buying it.

Following are some recommendations for overcoming trouble from gasoline boiling in fuel line and carbureter:

(1) The gasoline line from gravity or vacuum tank to carbureter should be free from coils or up-and-down bends, and should have a continuous downhill gradient from the tank to where it enters the carbureter. The gasoline line should not lie close to the exhaust pipe or the crankcase as these are usually very hot and may generate an extra amount of bubbles. In all the boiling observed the bubbles are small, about the size of an ordinary pinhead. If there is a continuous rise in the gasoline line they will ascend to the top of the main tank or vacuum tank, but if the line has vertical bends in it or long horizontal places, these bubbles join together to make big bubbles and may finally make an air lock and stop the fuel feed to the carbureter

(2) The hot air connection from the air heater on the exhaust pipe to the carbureter should be disconnected as long as the weather is warm. The vent

opening in the top of the float chamber should be enlarged to ⅛ in. or two 3/32-in. holes

It is obvious that nothing can be done to overcome the increased fuel consumption that will result from the use of this grade of gasoline in warm weather, except to use a different and less volatile gasoline.

ENGINE LUBRICATION

CORRECT lubrication for gas engines does not consist so much in the employment of high-quality oils as it depends on the selection of oils of proper specifications to meet the working conditions of the type of engine under consideration. I do not mean to say that quality is not an important consideration; far from it. It is the first consideration. The proper application of specifications is more difficult.

Nature has given us a great variety of crudes from which we have learned to refine oils of widely divergent characteristics. When properly refined, she has bestowed impartially on all a high lubricating value. The remainder of the problem is ours; to apply them properly.

Let us say we have an ordinary type of engine to deal with, forced-feed lubrication, cast-iron pistons, engine speed varying from 250 r.p.m. to an occasional 3000 under acceleration. This sounds simple enough but a careful analysis uncovers a variety of working conditions to be met during the course of a year's operation. The piston and bearing clearance of this engine are very small, just enough to allow safely for the expansion of metals when the highest operating temperature is reached.

In this case it is advisable to use an oil of medium viscosity, having a viscosity in the neighborhood of 200 at 100 deg. fahr. Saybolt Universal. This body will be found sufficient to seal the rings properly and hold up compression. Under quick acceleration to 3000 r.p.m. the oil will leap through the system rapidly and reach the bearings in time to maintain the all-important protective film. A heavy oil, especially in cold weather, functions doubtfully in this respect. Ten seconds frequently is ample for a bearing to melt after it begins to become overheated.

One of the most prolific sources of engine trouble in the winter is the employment of oils which become like vaseline when chilled, with the resultant inability of the pump to circulate them. It is astonishing to note how widely this simple but important factor of cold test is overlooked.

A Popular Misconception

A popular fallacy is that an oil must have a heavy syrupy body to be a good engine lubricant. This certainly has no foundation in fact. I am familiar with a road test in which the engine traveled some 40,000 miles without developing undue bearing clearances. This was accomplished by using a medium light oil and keeping it free from dust and other foreign materials. In the average well-designed engine of the type mentioned, a medium oil will show a normal mileage, about 700 or 800 per gal.

In cold weather we are prone, in starting an engine, to use the choke to excess, frequently forgetting to take it off until long after it is no longer necessary. Raw gasoline in considerable quantity gets into the crankcase, seriously impairing the lubricating function of the oil. When 1 lb. of gasoline is burned, 1½ lb. of water vapor is produced.

A portion of this water as steam is forced past the rings. In the heat of summer, this usually gets out of the breather pipe as water vapor. In winter, when the engine is started from a cold condition, it condenses into liquid water as soon as it strikes the cold crankcase. There should be a separation of the oil and water. If, from the use of improper oils which are emulsible with water, a finely divided emulsion occurs and the engine is subsequently left exposed to very low temperatures, a frozen engine frequently results. This obviously is due to fine crystals of ice between the bearing surfaces.

The working conditions of an engine having aluminum pistons are almost analogous to the cast-iron "job" with the exception of a larger piston clearance. This is necessary owing to the greater coefficient of expansion in aluminum. Here a heavier bodied oil is requisite to prevent overconsumption and to seal the pistons properly.

The question of proper flash and fire tests is important. The use of heavy high fire-test residual oils is to be avoided if possible, because they do not burn freely and clearly. As a result of this they are prone to deposit a gummy carbon in the explosion chamber and on the spark-plugs. Inversely, the use of an oil of too low a fire-test causes overconsumption. The consumption of oil in an engine virtually amounts to a slow destructive distillation and combustion process. With a well-adapted lubricant this process goes steadily forward leaving little or no residue.

Misuse of Lubricants

A striking example of the misapplication of a lubricant occurred at a flying field in Texas during the war. It was during the summer of 1918, when the thermometer stood daily at 110 in the shade. We were using Hispano-Suiza engines in Curtiss JN4H planes for aerial combat practice. This engine carrying aluminum pistons with the necessary large clearance required the use of a very heavy bodied oil. Through some inadvertence the supply of oil had become exhausted. It was a case of "hold up training" until more could be had or substitute a much lighter oil. It was decided to try the lighter oil. I was requested to experiment. Success was almost negligible. The light oil went past the pistons almost like water down a rat-hole. Before 1000 ft. had been gained, the engine was missing, the plugs being wet with oil. To make matters worse, drops of hot oil were coming out of the exhaust pipe, smearing the sides of the fuselage, and a goodly percentage was landing on the pilot's face. It did not take me long to kill the engine and spiral for a landing.

Every time a cloud of dust is encountered the oiling system gets its quota. This dust, be it ever so fine, helps to wear out the babbitt and produce loose bearings and worn surfaces. I have seen experiments which showed that an engine will double its ordinary life if the oil is perfectly clean. There is a big step to be taken in this field by the automotive industry.

If we would have correct lubrication, we must carefully analyze the working conditions under which the engine operates.—F. H. Floyd in *Petroleum Magazine*.

Presidential Address of J. G. Vincent

THOSE of you who attended the January dinner at New York, which marked the beginning of my administration, will remember that during my brief remarks I touched on the rapid growth of the Society and its increased opportunities and responsibilities. You will remember also that speaking on behalf of the officers elected for this year, as well as for those holding over, I urged the full cooperation of the membership of the Society at large, as I realized that we had a big job before us and needed all the help we could get. I want to take this opportunity to acknowledge the splendid support which we have received, and to urge your continued cooperation with a view to making our record this year one that we can all be proud of.

Before proceeding further I want to acknowledge the faithful attendance at meetings and the splendid cooperation of the Council. I consider myself fortunate indeed to have during my term in office the support and guidance of such a broad-gaged body of men as constitute our present Council. They have not only been faithful in their attendance at meetings but they have given careful consideration to and taken prompt action on all matters placed before them. I believe that no board of directors could serve their company more faithfully or intelligently than your present Council is serving the Society.

After giving the matter considerable thought, I have decided to divide my remarks into two general divisions, covering, first, Society and organization matters, and, second, reviewing briefly some of the problems confronting the automotive industry. I will first touch on the work of the administrative committees.

The Administrative Committees

One of the first matters to be given consideration at the beginning of this year was that of obtaining a proper increase in membership, as we realized that to cope properly with the many important problems before the Society we needed and deserved the full cooperation and support of everyone qualified for membership in the Society. Chairman W. A. Brush, of the Membership Committee, with his associates on the committee, deserves great credit for the very effective plan of procedure inaugurated on behalf of the committee. Two hundred and fifty applications for membership are directly traceable to the efforts of the committee, since its program was started in April. I wish to extend grateful thanks also to the more than 300 members of the Society who have been of active assistance to the committee.

The increase in the aggregate membership of the Society yearly since 1907 is shown by curve in the copy of the Society's membership roster for this fiscal year, sent the members recently. There was included in this book a table showing the respective residence of the members by States, in this country and abroad. One striking fact is that there are more members in New York State than in any other State in the Union, namely, approximately 850, Michigan following with 683, Ohio with 639, Illinois with 398, Pennsylvania with 323, and Indiana with 294. Varying numbers of members reside in other States, there having been at the time the book was issued one member in each of the following States: Mississippi, Montana, New Mexico and Utah.

We had on Jan. 1, 1919, 3865 members, and on Jan. 1, 1920, the membership had increased to 4516, making a net gain for the year of 651. So far this year we have added 398 members, bringing the total up to 4914; when it is considered that this represents but little more than five months of the year, I think you will agree with me that the Membership Committee is to be congratulated.

The Constitution Committee, of which D. L. Gallup is chairman, has given careful consideration to the amendments to the Constitution proposed at the last meeting of the Society.

The Finance Committee, H. M. Swetland, chairman, has given close attention to the expenditure of Society monies under the budget recommended to the Council, and has advised as to the investment of the surplus funds of the Society.

The House Committee, of which Past-president H. E. Coffin is chairman, is closely related to the Special Council Committee appointed early in the year for the purpose of advising on and formulating ways and means to secure the best results in an enduring way in the matter of the financing, housing and establishing of the Society in engineering circles in this country and abroad.

The matter of the housing of the Society has been settled for the time being at least by our having leased the entire seventh floor, 7500 sq. ft., in the Engineering Societies Building, New York City. These quarters are much more suitable and satisfactory than those occupied before by the Society in the same building. The dozen departments into which the Society staff is now divided, are located in view of the amount of contact they have with each other, and are equipped with uptodate means of inter-office communication, making for prompt and efficient service. A comfortable and satisfactory room has been reserved for the use of members visiting the office, and it is hoped that continuously increasing use of the rooms and service of the Society will be made by the members. If there proves to be sufficient demand, the Members' Room will be kept open after regular office hours.

The zeal with which the Meetings Committee, under the inspiring leadership of Chairman David Beecroft, has worked is evidenced by the assemblage here today. During the past several months the committee has held frequent meetings at regular intervals, and has spared no effort to provide for the members the best Summer Meeting possible, combining features of technical, social and recreational interest.

The Publication Committee under the guidance of Daniel Roesch is always ready to advise in the matter of facilitating the issuance of the publications of the Society in as good form as possible. There has been considerable unavoidable delay recently in the issuance of THE JOURNAL and the *Transactions* of the Society, owing to strikes and postwar conditions. THE JOURNAL is now, however, back again on its previous schedule. Part I of the 1919 *Transactions*, which will be about 50 per cent larger than any previous such semi-annual volume of the Society, is now on the press and subsequent volumes will follow as promptly as possible. The publication work of the Society is becoming more complex as well as greater in volume, as a result of its

activities in the various automotive fields, but the staff is being strengthened to take care adequately of this increased load.

The Society has in complete form a preliminary draft of manuscript for a handbook of aeronautical engineering, which it is proposed to issue after a proper amount of criticism and revision.

The Sections are, of course, a most important wing of our affairs. The eight existing Sections have held regular meetings during the past season and many valuable papers have been presented and discussed. The Sections Committee is directed by H. R. Corse, a former chairman of the Buffalo Section. A member of the Society office staff is now assigned to duty as Sections Secretary. There is little doubt that before long there will be established additional Sections in various parts of the country.

The Standards Committee, under the able guidance of Chairman B. B. Bachman, is constantly carrying on its important work. I want to acknowledge the loyal support I have received from Mr. Bachman. As I believe everyone is now aware of the essential nature of the standardization work, I will merely say that much additional standardization activity lies before us, particularly in the fields of tractor, aeronautic, motorboat and stationary engineering, and that plans are being carefully laid to carry forward our program as rapidly as practicable.

Special Committees

It has been necessary to appoint a number of special committees to handle adequately important problems before the Society.

The Automotive Fuel Committee made a report several months ago. Another report is to be presented at this meeting on the utilization of present fuels in present engines, so far as the installation of exhaust-heating devices is concerned, and the points contained in this report, as well as many others involved in the whole general problem, will be discussed at the Fuel Session of this meeting, in connection with which certain exhibits will be shown in operation. The Automotive Fuel Committee feels that 437-deg. fahr. end-point gasoline specification for summer and a lower end-point and corresponding initial point for winter can be readily met in automotive apparatus designed and to be designed. It is desired that the specifications suggested above be adopted by the respective oil producing and consuming industries and adhered to for so long a time as may be practical, due notice of any change to be given as far ahead as possible.

Much is expected of the committee which we have termed the Committee on Science of Truck Operation. F. W. Davis has accepted the chairmanship of this committee. The Society is also devoting considerable attention to the procedure of the National Highway Educational Conference. The National Automobile Chamber of Commerce, the Rubber Association of America, the Motor & Accessory Manufacturers Association and the National Automobile Dealers Association are cooperating in this work which it is intended shall determine certain educational policies of the automotive industry, furnish industrial information to technical colleges and in other ways assist in the conduct of automotive engineering courses at institutions of learning.

The Society Ordnance Advisory Committee, H. W. Alden, chairman, has held several sessions with officers connected with the Technical Staff of the Ordnance Department, which has recently developed much interesting automotive apparatus, a large part of which has very kindly been brought here by the department for the inspection and criticism of the members of the Society.

Members of the Special Council Committee attended a meeting held in Washington early this month for the purpose of considering the organization of American National, Regional, State and Local Engineering and Allied Technical organizations into a Federation. This unusually noteworthy gathering of engineers will, it is expected, result in The Federation of American Engineering Societies, which will succeed with expanded scope and representation to the Engineering Council, which has maintained an office in Washington for some time.

The Society has taken membership in the American Engineering Standards Committee and is now actively engaged on questions involved in the possible standardization in an international way of screw threads, ball bearings and specifications for aircraft material.

The Society is also continuing to cooperate with the Motor Transport Corps, which is to be transferred back to the Quartermaster Corps, and the Bureau of Standards in standards matters.

It is the policy of your officers to consider the various problems as they come up and deal with them as seems best, having in mind that we must endeavor to handle satisfactorily engineering problems which are of vital interest to the automotive industry, but that we do not want to increase our committees unnecessarily, thereby throwing an extra burden on our members.

The future of the Society is limited only by the growth of the automotive industry in its various fields. No man can say how great this will be, but clearly it is bound to be world-wide and of far-reaching magnitude in many fundamental and economic phases of civilization, the essence of these being transportation and utilization of the wonderful internal-combustion unit. It is the pleasure and duty of the Society to take a leading technical part in its scope of work, and to further the welfare work for engineers individually, which is now right before us in large scale. Progressiveness and democratic principles have been keynotes of the Society's activities, which places it in a correspondingly favorable position for the greater work to come.

Having now covered general Society and organization matters somewhat in detail, I will review some of the general problems confronting the automotive industry, as a wise solution of these is necessary to insure the proper growth of the industry. It naturally follows that the Society is vitally interested in the correct solution of these problems.

The automotive industry generally, and particularly those branches having to do with passenger cars and trucks, is today facing a number of vital problems which if not carefully and intelligently considered in all their phases, may have an adverse effect on not only the industry itself but on the economics of transportation.

The first of these problems is the outgrowth of the banking policy instituted by the Federal Reserve Board to bring about a sounder financial condition of the country through a general restriction of credit which has taken the form of a discriminating attitude by many bankers toward the automobile industry. The second of the problems pertains to possible adverse legislation which may be the direct result of not only mistaken attitude but of incomplete study and investigation of features of highway transportation. The third problem is the

rapid decline of our fuel reserve, indicating that unless our fuel production is enormously increased or conservation measures are instituted, a general restriction of the growth of the automotive industry will result.

Each of these problems is of vital economic import and their equitable solution can be accomplished only when the status of the automotive industry in our present economic scheme and the value of the motor car as a means of travel and transportation are fully appreciated.

Credit Restriction

Some time ago the Federal Reserve Board, in an endeavor to halt feverish speculation and undue expansion, announced that higher discount rates on commercial paper would be instituted. After successive unheeded warnings this policy was carried out. Later it was found necessary to again increase the discount rates. But the evils of credit inflation were only temporarily deterred, seemingly proceeding with increased stimulation after each period of depression. In a final attempt to bring about a better financial condition the Federal Reserve Board adopted the policy of general credit restriction. Some of the member banks have endeavored to define "essential" and "non-essential" commodities. The non-essential commodities are, of course, discriminated against in the making of new loans or the discounting of credit paper. Some bankers have included the automobile among the non-essentials. Whether this course is justified, time and experience will determine. The motor vehicle has built up an industry in this country second in importance only to that of the steel industry. I think you will all agree with me that the automobile is decidedly not a luxury, many people who are not identified with the industry to the contrary notwithstanding. That the motor car has a very definite position in our transportation methods can be shown readily by tracing briefly the evolution of transportation in the economic history of this country. In the days before the steam locomotive the principal development of the country took place at the Atlantic seaboard and inland along the navigable rivers and the shores of the Great Lakes. Even then it was found necessary in the development of classified labor for communities not connected by water-ways to carry on trade. Travel between these points was accomplished by stages, merchandise being transported on the famous freight wagons.

The development of the country during this period was particularly slow. The various communities tried to produce everything they needed. After the steam railroad became a practical means of travel, the growth of the country was proportional to the rate at which railroad systems expanded. Division of labor became more intense, specialization in the industries developing along the lines particularly adapted to local conditions. However, the distribution of population was naturally confined to the territory contiguous to the routes of travel and commerce. This particular kind of development took place until the advent of the automobile, and through its widespread use advancement in the rural districts assumed quite a different aspect. The motor car was the great missionary which obtained for the farmer the vast movement for road improvement. The resultant economic value to the farming industry is plainly evident. Compare the twenty-year period before the automobile with the sixteen-year period following it. An average increase in farm values of $400,000,000 annually was made during the twenty-year period preceding the end of 1900. During that time the population of the United States increased 50 per cent, or at the rate of 2½ per cent per annum. During the sixteen years following farm values increased at an average rate of $1,300,000,000 a year; the population increased during the same period 33 per cent. This shows that during the twenty-year period with the population increase of 50 per cent farm values increased 57 per cent, whereas during the sixteen-year period, with an increase in population of only 33 per cent, farm values increased 100 per cent.

Of the total number of motor cars registered in the United States in 1919, nearly one-third were owned by farmers. This is due partly to the greater accessibility to the more remote sections which previously required from several hours to a day or more to reach from the nearest railroad or town.

The passenger car possesses utilitarian features for not only rural use but for universal betterment of community life. Previously, when the sole means of transportation in our large cities was street railways, municipal development took place in a similar manner, expansion occurring in those districts within easy walking distance of the car lines. At the present time these restrictions do not apply in even a small degree. The passenger car, to some classes of professional and business people, has become indispensable as a means of transportation in the conduct of business tuned to the present standards of expediency and efficiency.

I believe that there are no arguments against the economic value of the commercial car; it is no longer necessary to prove to the business man that the motor truck can be used to advantage in business. However, those dealers who are identified with both passenger-car and commercial-car business will probably suffer a curtailment of credit because the passenger car is considered by some persons of mistaken attitude as solely a pleasure vehicle.

Another important factor which demonstrates the economic value of the truck and the motor car in our present social structure is the important position which the automotive industry holds in our present industrial scheme. In 1919 the wholesale value of the combined production of passenger and commercial cars amounted to more than $1,885,000,000, and it is estimated that if the value of parts and accessories manufactured during this period were added, the amount would be more than $2,500,000,000, involving the payment in wages and salaries of nearly $814,000,000. These figures do not include the thousands of persons engaged in the retail phase of the business and those who are employed in allied industries which depend for their support solely on the demands created by the use of motor vehicles.

Business adjusts itself to improvements. As the railroads developed, telegraph, telephone and other modern apparatus came into general use, and time-saving and increased facility became fixed standards in the transportation of goods and the transmission of intelligence. From small beginnings corresponding industries became of great importance, not only in the use of finished product but fundamentally in the employment of capital and labor. So with the motor car industry; it has grown from the dream of the early inventor to the mammoth proportions of the greatest industry in the world.

Highway Improvement

The second problem requiring serious attention relates to legislation pertaining to the construction and maintenance of improved highways and the necessary

appropriations to carry out any constructive program. There has been much evidence of attempts to pass legislation which would have been not only unfair but absurd. This resulted in part from inadequate study of the problem and the idea that roads possess certain rights regardless of their limitations in withstanding standard traffic. When the passenger car became considered as a standard means of transportation, the value of improved roads was generally appreciated and a nation-wide good roads movement started. The passenger car did not present very difficult problems concerning types of highway construction. With the increased use of the commercial car the problems of road construction became very different. With the extended application of the motor truck, the problems became more and more serious. The real test came during the winter of 1917-1918 when the combined effect of an extremely hard winter and the tremendous demand for the transportation of war munitions and supplies broke down the railroad service throughout the territory east of the Mississippi. The motor truck was pressed into service and during the period mentioned more than 1,200,000,000 tons of freight was moved by truck.

Firmly established as an economic carrier, the use of the motor truck is being more and more extended for short-haul transportation. The present critical condition of railroad service accentuates this condition. As a result of this wide application of the truck deterioration of highways has been extremely rapid. Some of the roads have been partially rebuilt but of the same construction as originally and as a consequence they are soon destroyed. The importance of improved highways to the economic operation of the motor truck cannot be over-emphasized. For the general benefit of the public the wider use of the motor truck should be fostered and in no way restricted.

We all appreciate that transportation is one of the basic forces in the economic structure of society and that the cost of transportation is an important element affecting prices. Recent experience in the use of trucks has shown that for certain classes of goods the motor truck can compete with the railroads in cost of transportation for distances up to 200 miles, while the service rendered is comparable with that offered by express companies. The effect of good roads in decreasing the cost of motor-truck service should be reflected in decreased prices to the public. Quicker deliveries can be made because higher truck speeds are possible. Delays caused by accidents incident to bad roads are eliminated. This increases the daily range of action, resulting in greater mileage and consequent lower cost per mile. Due to the decreased tractional resistance of good pavement, fuel consumption is materially reduced, especially in facilitating high-gear driving. Tire mileage is increased and the depreciation is materially reduced.

The legislatures are morally bound to provide appropriations for highways suitable for trucks. The many problems involved should be thoroughly studied in order that the most economical balance can be maintained. Not only must present conditions be considered but the anticipated extension of the use of the motor truck should be taken into account. Types of commercial cars should be studied with special reference to weight, speed, load distribution and tire equipment, and every effort should be made to construct roads than can withstand the traffic of present-day vehicles, the standards of which are fairly well established. Obviously, after an exhaustive study of these important items, the most economic selection will be that which facilitates the application of the truck to the greatest degree, but at the same time represents the lowest cost to the State over a period of years.

Fuel Problem

The third problem, and no doubt the most important, upon which the future of the automotive industry depends, is the fuel problem. Many comprehensive papers and discussions on this subject have been presented on former occasions. The problem has now developed to the point where a substitute for our present fuel or radical steps toward its conservation must be instituted. Every effort is being made by both governmental and private interests to obtain the greatest quantity of gasoline from its derivatives. Extensive research on fuel substitutes is being carried on, but apparently no definite solution has been advanced. Aside from the possibility that new oil fields will be opened, the immediate future seems to point to fuel conservation as one of the most available expedients.

Fuel conservation can be materially advanced by designs for more efficient utilization of fuel in motor cars. There is no doubt that continued effort in this direction would result in the development of vehicles having fuel economy much superior to present-day standards. The tractor, the marine and the stationary engine industries, in common with the passenger-car and the truck interests, have some real problems before them, which must be satisfactorily solved to insure their continued development and increased range of usefulness. I do not know to what extent banking policies will affect these industries, and I assume that road development will have little, if any, direct bearing on them, but clearly the fuel problem applies to all industries which depend on the internal-combustion engine for motive power.

The question might be advanced as to what bearing the problems of banking policy, road legislation and fuel conservation have on this Society of engineers. You can all help to assure an equitable banking policy by word-of-mouth propaganda, asserting pride in your connection with an industry not engaged in the production of luxuries but in building transportation, that basic necessity in the economic welfare of the world. As roads are to motor transportation what rails are to the railroad, it is your duty to take part in the selection of capable legislative bodies which will father constructive legislation, not alone in matters pertaining to the automotive industry but in all matters of concern to the welfare of the Nation. Your duty to society and your country calls for your support in civic affairs. As engineers, your knowledge of the fuel situation presents an incentive for the design of more efficient vehicles of transport. Let our past great achievements serve as a stimulus to greater effort.

Aeronautic Development

Coming now to a consideration of the newest and fastest form of transportation, the airplane, we face some problems of an entirely different nature. Our most important problem, as I see it, is to build a real industry around the airplane, as when this is accomplished the minor problems can be more easily handled. The

(*Concluded on page* 214)

Intake-Manifold Temperatures and Fuel Economy

By W. S. James,[1] H. C. Dickinson[2] and S. W. Sparrow[3] (*Members*)

Semi-Annual Meeting Paper *Illustrated with* Drawing, Charts and Photographs

LAST year the Committee of this Society on the Utilization of Present Fuels in Present Engines decided to promote a "more-miles-per-gallon" movement by publishing a report on the economy to be secured by applying the correct amounts of heat at the intake manifold. It soon appeared that there was some general information, much supposition and a decided lack of definite information on certain phases of this subject. After the committee had prepared a report dealing with the present state of the art as regards hot-spots, heated air, etc., it was decided to supplement this by a special series of experiments which might yield more information than was then available. The Bureau of Standards was requested about May 1, 1920, to undertake this work.

The program for this series as outlined by the committee included measurements of engine performance under conditions of both steady running and rapid acceleration with different temperatures of the intake charge secured by three different methods, (*a*) the hot-air stove supplying heated air to the carbureter, (*b*) the uniformly heated intake manifold and (*c*) the "hot-spot" manifold. Fuel economy was to be determined for both part and full-throttle operation.

Engine and Testing Equipment

The committee procured through the courtesy of one of the large automobile builders an engine typical of modern six-cylinder design. This engine was particularly well adapted to the purpose in hand, having a two-port intake manifold with a minimum length of passage within the cylinder-block, an exhaust manifold conveniently located for installing special exhaust openings, rather high peak load speed and conventional general design.

The problem presented is not one of carbureter performance under different load and speed conditions but rather one of engine performance as affected by the intake temperature and the air-to-fuel ratio, both being adjusted independently for each condition of running. The engine and the carbureter are to be considered in this case as merely experimental tools whose individual characteristics are eliminated so far as possible in an attempt to secure definite and measurable conditions of the intake charge and accurate and impartial measurements of the behavior of the charge as indicated by fuel consumption in pounds per brake-horsepower-hour. The carbureter was selected with these requirements in view. Several different engines and carbureters would have been used if time had permitted.

As it was important to secure a maximum of reliable information from a necessarily brief series of tests, provision was made for an unusually complete series of measurements. The engine was coupled to a 50-hp. Sprague dynamometer, with a flexible disk and a spline coupling, the arrangement being shown in Fig. 1. In addition to fuel consumption measurements by direct weighing, a gasoline flowmeter loaned to the Bureau by Major Schroeder of the Air Service proved to be of great service in adjusting the carbureter for the different mixture ratios. Air-flow was measured by thin-plate orifices.

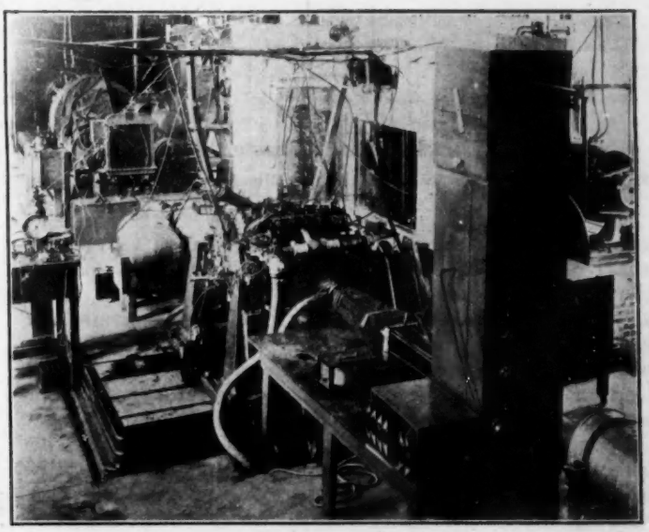


Fig. 1—The Arrangement of the Engine and the Testing Apparatus

An electric heater was used to control the intake air temperature, the main heating being produced in an exhaust-jacketed section of the intake pipe in which were brazed radial fins of copper extending into both the intake pipe and the exhaust jacket. A rise of temperature of about 150 deg. cent. (302 deg. fahr.) could be produced by the electric heater and about 85 deg. cent. (185 deg. fahr.) rise at full throttle by the exhaust stove. Time did not permit of connecting to a refrigerating system to supply air colder than room temperature. Temperatures were measured by thermocouples at about twenty-five points in and around the intake manifold.

For acceleration tests with different air-fuel ratios, a flywheel consisting of a 33-in. steel disk, ½ in. thick, was mounted on the dynamometer shaft. The inertia of this flywheel added to that of the dynamometer armature is about equal to the inertia of a 3500-lb. car on direct drive, assuming a gear ratio of 5 to 1 and 32-in. wheels. This inertia disk was used only in connection with the special acceleration tests, being removed for the constant-

[1]Associate physicist, Bureau of Standards, Washington.
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[3]Associate mechanical engineer, Bureau of Standards, Washington.

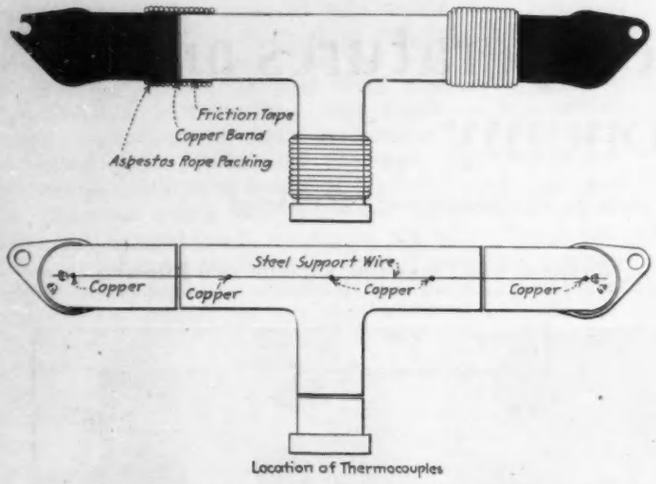


FIG. 2—THE SPECIAL GLASS MANIFOLD USED IN THE PRELIMINARY TESTS

speed runs to avoid its windage load and to relieve the shaft of unnecessary punishment. The windage load of the flywheel is not important in the acceleration runs, as in these it was necessary only to set for the same load each time. The windage resistance of the disk increases with the engine speed at the same rate as the windage load on a car when accelerating and therefore assists in attaining a closer approximation to the car load.

To obtain visual observations and photographs of the behavior of air-fuel mixtures in the manifold under different conditions of temperature, speed and throttle opening, the tee portion of a manifold was made of Pyrex glass. (See Fig. 2.) Temperatures in the mixture stream were measured by a series of thermocouples mounted within the manifold.

The experimental manifold for the main series of observations was designed to serve as a "hot-spot" manifold, exhaust-jacketed manifold, or a cold manifold as desired. The intake portion of the manifold was of cast iron and approximately the same inside diameter as the manifold furnished with the engine. Thermocouples were peened into the metal walls of the intake manifold and afforded means for measuring the wall temperatures. A partitioned exhaust jacket surrounding the intake manifold afforded a means of heating the tee alone or the manifold as a whole. Heat control was effected by throttling the exhaust entering and leaving the jacket sections and a main exhaust line, thus obtaining the three manifold conditions mentioned above.

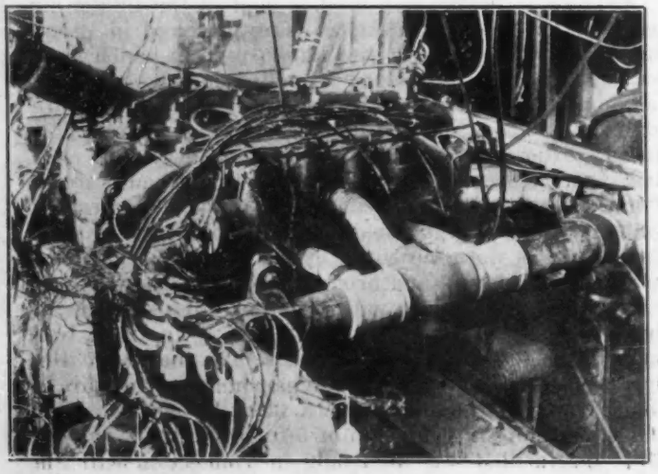


FIG. 3—THE TYPE OF EXHAUST MANIFOLD USED IN THE TESTS IN PLACE

PRELIMINARY TESTS

Before starting the main series of runs with the exhaust-jacketed intake manifold a series was made with one having the tee section of Pyrex glass to see the condition of the charge entering the cylinders. This series covered a range of speeds and loads from 650 to 2200 r.p.m., and from idling to full load. Motion pictures were taken of the manifold in an endeavor to make a permanent record of the phenomena observed.

In but one of the runs were the inside walls completely dry. This condition was attained only with great difficulty by the direct application of the flames from two brazing torches to the glass tee. During this run no heat was supplied to the intake air. It was impossible however to dry the walls of the manifold solely by heating the air entering the carbureter to as high

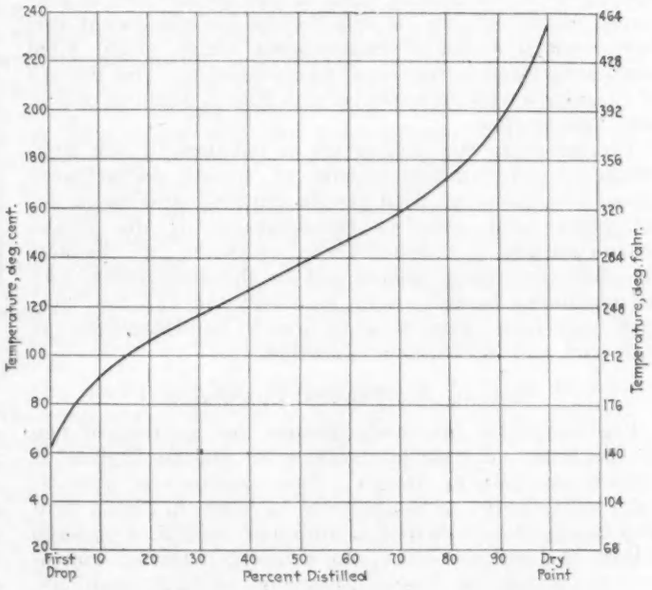


FIG. 4—DISTILLATION CURVE OF THE FUEL USED

a temperature as possible, 240 deg. cent. (464 deg. fahr.), the walls still being covered with a rather thin oily film creeping toward the intake ports. The greatest amount of liquid was present in the manifold at 650 r.p.m. and full throttle, the layer being at least 1/16 in. deep in some places. The liquid collected mainly on the lower side of the manifold between the tee and the intake ports. Liquid particles in the airstream were carried against the upper side of the manifold above the carbureter throat and kept this portion wet at all times. When the tee was heated with the brazing torch a great difference was observed in the ease with which heat could be supplied to the liquid on the walls. The liquid striking the top of the manifold had sufficient velocity to make good thermal contact with the wall and hence was readily evaporated. On the bottom of the horizontal portion of the manifold where the puddles were relatively deep the vapor formed would insulate the liquid above it from the wall, thus making evaporation more difficult. When the glass wall reached a high temperature the liquid fuel assumed the spheroidal state and behaved as

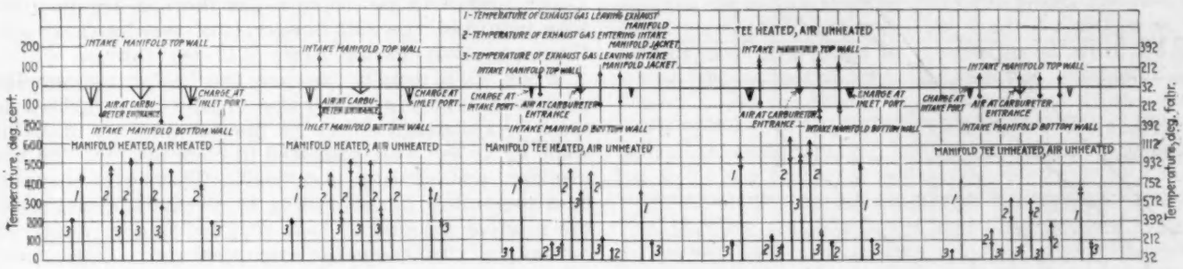

Temperature, deg. cent.
Temperature, deg. fahr.
MANIFOLD HEATED, AIR HEATED
MANIFOLD HEATED, AIR UNHEATED
MANIFOLD TEE HEATED, AIR UNHEATED
MANIFOLD TEE UNHEATED, AIR UNHEATED

FIG. 5—TYPICAL CURVES SHOWING THE MANIFOLD WALL AND CHARGE TEMPERATURES

water does when dropped on very hot metal. The liquid which collected on the lower wall of the manifold came from the inside surface of the vertical section of the tee, being finally eliminated by heating this section instead of the spots where it collected.

The amount of heat necessary to vaporize the liquid on the walls when no heat was applied to the inlet air was surprising. The full blast of a ½-in. torch would just dry the top of the manifold. If the torch were removed for as much as 5 sec., the wall would again become wet. Fog was present in the mixture stream only when the intake-air temperature was below about 90 deg. cent. (194 deg. fahr.).

MAIN SERIES OF TESTS

The manifold with the glass tee was then replaced by the one with the exhaust jacket which is shown in position in Fig. 3 and the main series of runs commenced. In preparing the program for these tests, this question was asked, "What does the car owner most desire?" It was decided that the answer is, "low fuel consumption and rapid acceleration." Hence the problem was essentially to determine how the attainment of this result is influenced by changes in the amount of heat furnished the intake charge or in the method of supplying this heat.

The fuel consumption tests were made at both full and half load at speeds of 650 and 1200 r.p.m. These conditions were selected as covering the range of average driving from 15 to 25 m.p.h. After each adjustment of quantity or method of charge-heating, the engine was operated with from three to five different air-

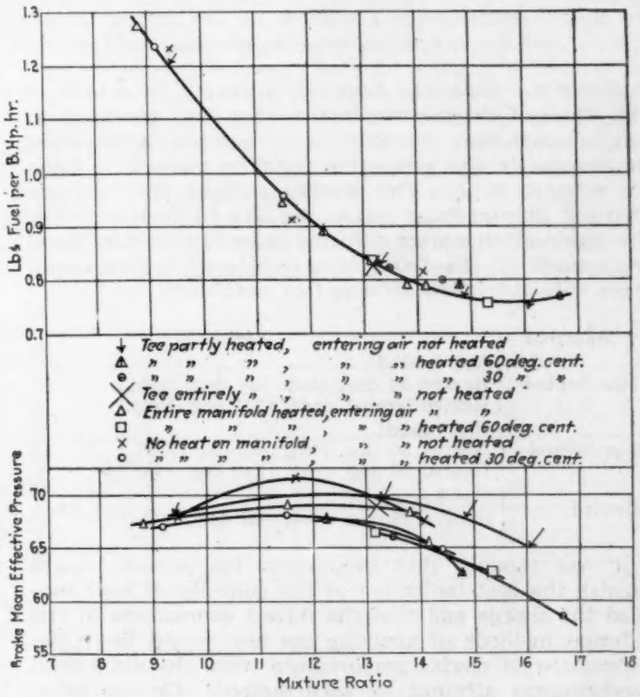

Lbs Fuel per B.Hp. hr.
Tee partly heated, entering air not heated
Tee entirely " " not heated
Entire manifold heated, entering air " "
No heat on manifold, " " not heated
Brake Mean Effective Pressure
Mixture Ratio

FIG. 6—RESULTS OBTAINED AT A SPEED OF 650 R.P.M. WITH A WIDE-OPEN THROTTLE

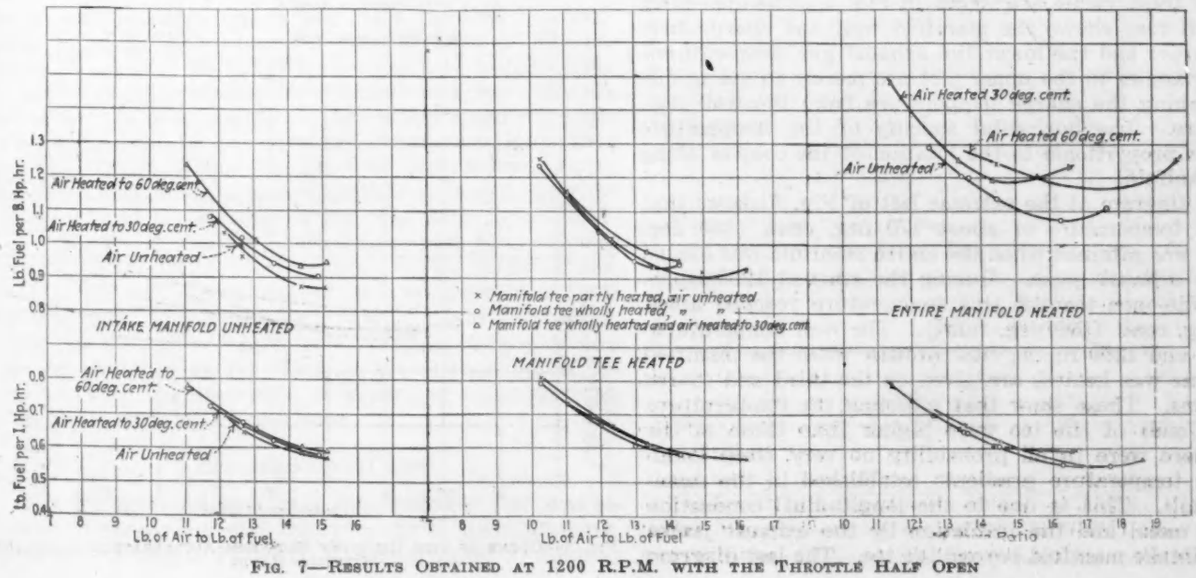

Lb. Fuel per B.Hp. hr.
Air Heated to 60deg. cent.
Air Heated to 30deg. cent.
Air Unheated
INTAKE MANIFOLD UNHEATED
Lb. Fuel per I. Hp. hr.
Lb. of Air to Lb. of Fuel
× Manifold tee partly heated, air unheated
○ Manifold tee wholly heated, " "
△ Manifold tee wholly heated and air heated to 30deg. cent.
MANIFOLD TEE HEATED
ENTIRE MANIFOLD HEATED

FIG. 7—RESULTS OBTAINED AT 1200 R.P.M. WITH THE THROTTLE HALF OPEN

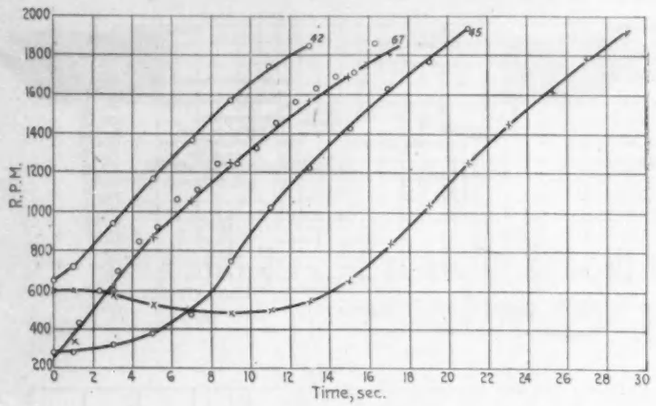


FIG. 8—TYPICAL SPEED-TIME CURVES

fuel ratios. This was done not primarily to determine the effect of the mixture ratios upon fuel consumption but in order that the ultimate comparison of the effect of changes in charge-heating could be made at a definite mixture ratio. The throttle position was left unchanged throughout a series, but the air-fuel ratio and the spark-advance were adjusted prior to each run. Runs were made at the four above-mentioned engine conditions with the following manifold conditions:

Manifold	Air
Not heated	Not heated Heated 30 deg. cent. (86 deg. fahr.) Heated 60 deg. cent. (140 deg. fahr.)
Tee heated	Not heated Heated 30 deg. cent. (86 deg. fahr.) Heated 60 deg. cent. (140 deg. fahr.)
Heated	Not heated Heated 30 deg. cent. (86 deg. fahr.)

It was thought that intake-port temperature might furnish the best indication of the quantity of heat supplied the charge and that the fairest comparison of the different methods of applying the heat might lie in the comparison of engine performance when the same temperature was attained by each method. On the other hand, the measurements of the manifold wall-temperatures and exhaust-gas temperatures were made primarily to indicate the distribution of the heat supplied. A few of these values are shown in Fig. 5. The upper plot in each case shows the manifold wall and charge temperatures; and the lower the exhaust gas temperatures. The triangles in the upper plot are merely to aid in distinguishing the charge temperature from the wall temperature. The horizontal spacing of the temperature lines is proportional to the location of the couples along the manifold.

The diagram at the extreme left of Fig. 5 shows that a wall temperature of about 170 deg. cent. (338 deg. fahr.) was attained when the entire manifold was heated by the exhaust gases. During the runs at 1200 r.p.m. and wide-open throttle this temperature reached about 310 deg. cent. (590 deg. fahr.). The wall temperatures at 650 and 1200 r.p.m., full throttle, when the manifold tee alone was heated, are given on the third and fourth diagrams. These show that although the temperatures at the ends of the tee were higher than those at the ells, there were in all probability no very steep longitudinal temperature gradients established in the manifold walls. This is due to the longitudinal conduction of the metal and the insulation by the exhaust jacket of the intake manifold beyond the tee. The last diagram shows that with no exhaust gas flowing around the intake manifold, its wall temperature was uniform and in this case about 50 deg. cent. (122 deg. fahr.).

When, as is usually the case, the fuel is not completely vaporized before entering the engine, any further heat must be furnished either by the hot piston and cylinder walls or by the heat produced in compression. To measure this heat directly is difficult. There was thought to be a possibility of estimating by pressure measurements the relative amount of heat supplied under various conditions of intake-charge temperature. The method adopted was to take readings on each test, at points on the compression stroke 150 and 45 deg. before the upper dead center, with the pressure indicator developed by the Bureau. The former is the closing point of the intake valve, and the value of 45 deg. was chosen as a convenient point just before the maximum spark-advance. The effect of supplying heat to the charge during the compression stroke is to increase the ratio of pressures measured at these points. With the engine driven by the dynamometer at 1200 r..p.m., half throttle, this ratio was found to be 3.7; under power with other conditions unchanged the ratio was 3.4. The probable proper interpretation is that under power the heat supplied to the charge by the piston and walls was too small to evaporate the fuel that entered the engine, and as a result some of the heat developed in compression was used for this purpose, decreasing the ratio. There was not sufficient time to analyze these results thoroughly but it was considered worth while to describe the method as being one possible way of securing an answer to a question very pertinent to this subject.

Figs. 6 and 7 show the results obtained with different charge-temperatures. The changes in fuel consumption in pounds of fuel per brake-horsepower-hour are most apparent at half throttle. It was not evident how much of this change was the effect of the charge condition and how much was due to the resulting change in engine power. To determine this, friction-horsepower measure-

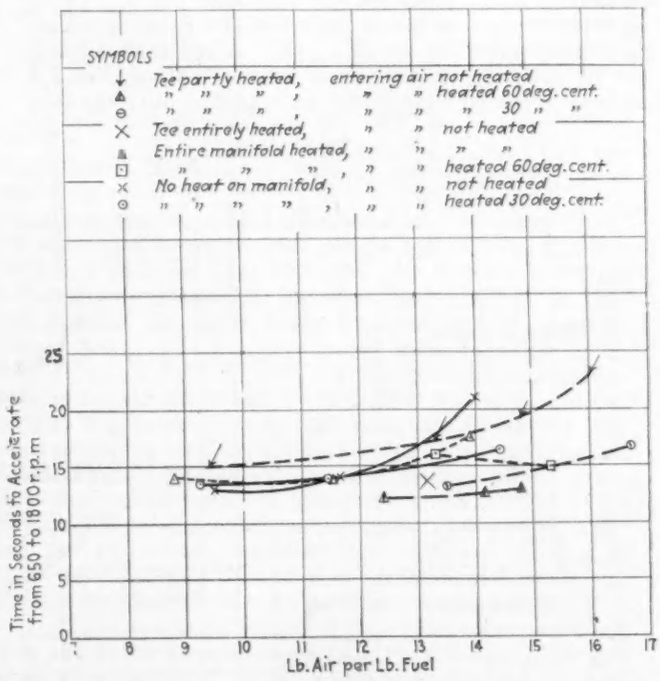

SYMBOLS
Tee partly heated, entering air not heated
" " " " " heated 60 deg. cent.
" " " " " " 30 " "
Tee entirely heated, " not heated
Entire manifold heated, " " "
" " " " heated 60 deg. cent.
No heat on manifold, " not heated
" " " " " heated 30 deg. cent.
Time in Seconds to Accelerate from 650 to 1800 r.p.m
Lb. Air per Lb. Fuel

FIG. 9—CURVE OF THE RELATION BETWEEN ACCELERATION TIME AND MIXTURE RATIO

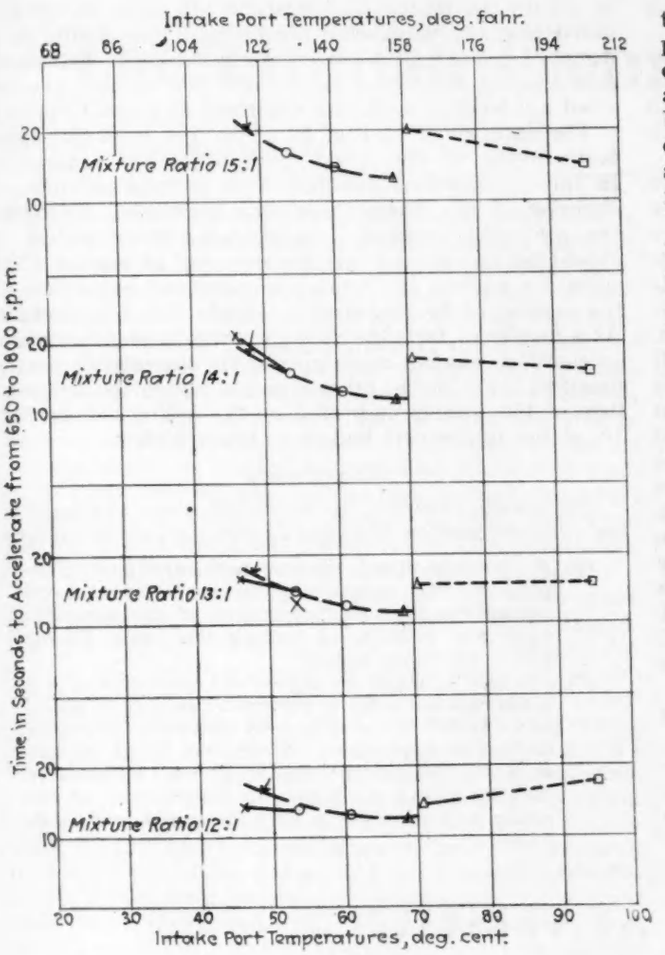

Intake Port Temperatures, deg. fahr.
68 86 104 122 140 158 176 194 212
Mixture Ratio 15:1
Mixture Ratio 14:1
Mixture Ratio 13:1
Mixture Ratio 12:1
Time in Seconds to Accelerate from 650 to 1800 r.p.m.
20 30 40 50 60 70 80 90 100
Intake Port Temperatures, deg. cent.

FIG. 10—CURVE OF TIME OF ACCELERATION AND INTAKE-PORT TEMPERATURES

ments were made under the same conditions as when the engine was operated under power. From these measurements and those of the brake horsepower, the indicated horsepower was determined and the pounds of fuel consumed per indicated-horsepower-hour consumed. The lower curves show that on this basis the fuel consumption per indicated horsepower remains substantially the same throughout all the charge conditions tested. This is well borne out by the curves mentioned, for while the differences in consumption on the brake-horsepower basis are often large, on the indicated-horsepower basis they are in general within the limit of experimental error. An examination of the curves on this basis will show the differences to be less than 4 per cent with three different methods of heating, with intake-port temperatures ranging from 48 to 96 deg. cent. (118.4 to 204.8 deg. fahr.), and with carbureter-air temperatures from 30 to 90 deg. cent. (86 to 194 deg. fahr.). Over this range, then, the method and amount of heating to be employed can be governed by its effect on the acceleration of the engine, with the assurance of producing no appreciable change in economy of operation.

ACCELERATION TESTS

For the acceleration runs a dynamometer load was selected to correspond with that of a car at about 45 m.p.h. with full throttle. This load was determined by running the engine at full throttle and 2400 r.p.m. and noting the position of the dynamometer control-resistances. The engine was then idled at a slow speed with the resistances set as noted and the throttle suddenly opened. Under these conditions the inertia load of the flywheel corresponded to the inertia load of the car, and the load-speed characteristic of the dynamometer approximated its wind and frictional resistances.

Prior to the acceleration test the engine was run at full throttle and 650 r.p.m. and observations were made of power, fuel consumption, air-flow, pressures and temperatures. The throttle was then closed until the engine speed dropped to 650 r.p.m. with the control resistances changed to those determined for full throttle and 2400 r.p.m. Then the throttle was suddenly and completely opened and at the same time a chronograph which recorded time and engine revolutions was started. Readings of the engine speed also were taken on a tachometer of the chronometric type which indicated at intervals of 2 sec. the average number of revolutions per minute during the previous 2 sec. When the engine speed reached 1800 r.p.m. the throttle was closed and the run repeated. The carbureter setting was then changed and another set of observations made at 650 r.p.m. and full throttle, and the acceleration again measured. After at least three mixture-ratio settings were made the amount

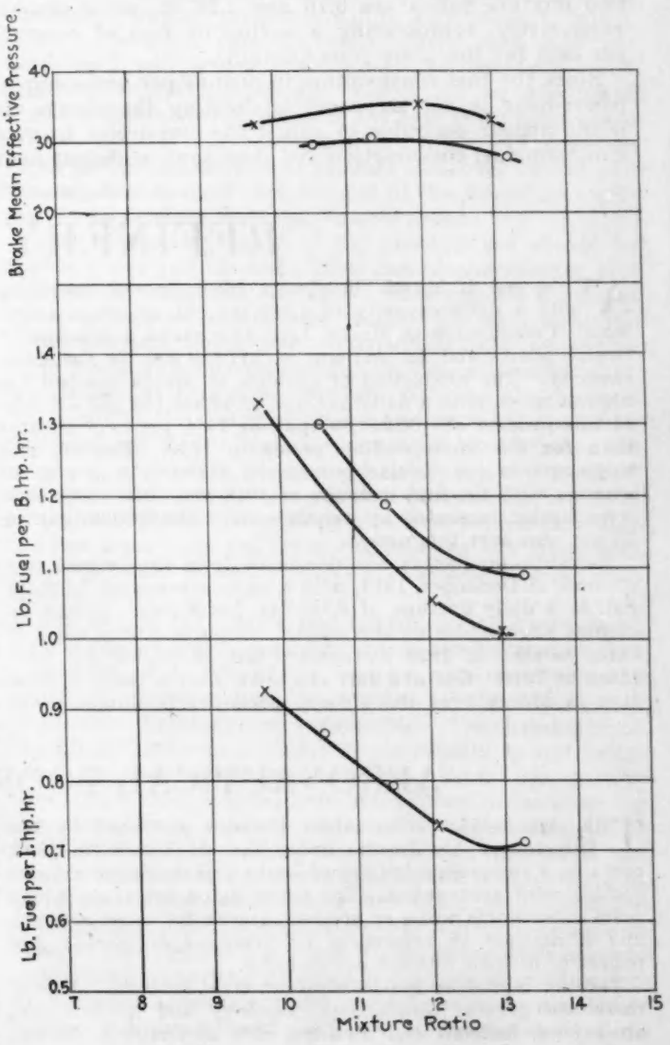


FIG. 11—EFFECT OF SMALL THROTTLE CHANGES

of heat supplied the intake manifold was changed and the runs were repeated.

The measurement of mixture ratios during acceleration was not attempted. It was assumed that changes in the method or in the amount of charge-heating would not affect the metering characteristics of the carbureter when accelerating.

In this manner the data shown on curves in Figs. 8 to 11 inclusive were obtained. Typical time-speed curves are reproduced in Fig. 8. Runs Nos. 42 and 45 were made with the same carbureter setting, giving a mixture ratio of 9.4 to 1 at 650 r.p.m. and wide-open throttle, with no heat supplied to the air entering the carbureter. Curve 45 shows the acceleration from 300 r.p.m. It should be noted that above 850 r.p.m. the slopes of all the curves are about identical. Fig. 9 shows the time in seconds required for the engine to accelerate from 650 to 1800 r.p.m. with different mixture ratios and with six different conditions of heating of the intake charge. In every instance but one the time required for acceleration was less the richer the mixture. Also with any given condition of manifold heating and mixture ratio, when additional heat was supplied by heating the intake air the acceleration times decreased. The same acceleration time was attained with a heated 15.3 to 1 mixture as with an unheated 9.4 to 1 mixture. The fuel consumption at full throttle and 650 r.p.m. for these two mixture ratios are 0.76 and 1.26 lb. per b.-hp.-hr. respectively, representing a saving of fuel of over 60 per cent for the same power outputs.

Since the fuel consumption in pounds per brake-horsepower-hour is not increased by heating the charge, it would appear desirable to adjust the carbureter to give minimum fuel consumption and then apply sufficient heat to obtain the desired acceleration. It must be remembered that an increase in air temperature results in a decrease in the engine power at full throttle. The manifold adopted will hence be the one that secures the desired acceleration with the minimum decrease in power.

The data given in Fig. 10 show that with the same temperature at the intake port there are differences in the accelerations attained with various methods of charge-heating. From these plots the heated tee seems the preferable method. In studying these curves it should not be assumed that the power of an engine is the same for a given intake-port temperature, regardless of the method of heating used to obtain this temperature. As a matter of fact, the drop in power to obtain a given acceleration was not much greater for the entirely heated manifold than for the other types, although the temperature of the former, indicated by the dotted line in Fig. 10, at the intake port had to be much higher.

Conclusion

The results obtained in the month since the committee's request was received can be summarized as follows:

(1) At constant speed, mixture ratio, and power output, the fuel consumption in pounds per brake-horsepower-hour is independent of the temperatures and methods of heating the intake charge within the range tested

(2) The rate at which an engine will accelerate with a given mixture ratio, or carbureter setting, is markedly affected by the amount of heat supplied and its method of application. Within the limits of this work the greater the amount of heat supplied to the charge and the higher its temperature at the intake port the more rapidly the engine will accelerate

REFINERY STATISTICS

AT the end of March there were 265 refineries operating with a daily capacity of 1,560,345 bbl. of crude petroleum. Compared with March, 1919, this shows a decrease of twelve plants and an increase of 317,680 bbl. in the daily capacity. The production of gasoline in March reached the highest point, with a daily average of 11,843,151 gal. Stocks of this product are 80,000,000 gal. or 14½ per cent greater than for the corresponding period in 1919. Exports and shipments to our insular possessions maintained a general average with the first quarters of 1918 and 1919. Domestic consumption increased by approximately 200,000,000 gal. or 33 per cent over this period.

Kerosene production has decreased from the largest production, in December, 1919, with a daily average of 7,402,467 gal. to a daily average of 6,164,844 for March. Stocks increased slightly during this month. Exports during the first three months of 1920 increased about 50,000,000 gal. over those of 1919. Gas and fuel oils show an increased production in March over the amount produced in January and February. Stocks have been decreasing since the end of September, 1919, and are now approximately 170,000,000 gal. less than a year ago. Exports of fuel oil increased in the first quarter of 1920 by 155,000,000 gal. over the exports of 1919. Domestic consumption increased 245,000,000 gal. or 18 per cent over the exports of 1919. It is interesting to note the large increase in the bunker oil for steamships in the first quarter over the same period of 1919 which amounts to 2,982,000 bbl. The production of lubricating oils in March is the largest for the last three years, with a daily average of 2,639,322 gal. Stocks have decreased by 7,000,000 gal. since the first of the year. Shipments and exports for the first quarter increased 30,000,000 gal. or 40 per cent and domestic consumption increased 38,000,000 gal. or 39 per cent over the first quarter of 1919. To meet these increases in production it was necessary to draw upon stocks of crude oil to the extent of 3,373,000 bbl. in this period in spite of increased production and importation of petroleum.—Compiled by H. F. Mason for United States Bureau of Mines.

AERONAUTICAL BOOK AND MAGAZINE LIST

THE Air Service Information Circular published by the Director of Air Service under date of March 29, 1920, contains a comprehensive list of books and magazine articles dealing with aeronautics. The books listed are those which seem most worth while or are best known for other reasons, and a number of references to principal documents and papers of historic interest are included.

The list is divided into thirty-four main subjects. Among these are general terminology, aerology and meteorology, air screws, balloons and airships, civil aeronautics, design, engines and turbines, gyroscopes, hydroairplanes and flying boats, kites, laboratory reports and experimental data, legal aspects of flying and state and local laws and ordinances, military and naval aeronautics, operation and navigation, photography and mapping, theory and mathematics and Army and Navy Air Services. A list of aeronautical journals and another of publishers of aeronautical books are included. Copies of the circular can be secured for a nominal sum from the Superintendent of Documents, Government Printing Office, Washington.

The Human Element in Production

By A. F. KNOBLOCH[1] (*Member*)

SEMI-ANNUAL MEETING PAPER

THE human element in industry and production is the one fundamentally essential element; all other elements are supplemental in their relation. Modern machinery supplements the human effort; it does not supplant it. The modern farm, with all its equipment including the truck and tractor, still requires the farmer. He has been, it is true, supplemented by this modern equipment and thereby made much more efficient, so that he is able to produce more than he was able to produce without such equipment. It is essential that he be furnished this equipment, including trucks and tractors, when they are required by him in the raising and transporting of foodstuffs, especially in these days when the wastage of war is demanding of the American farmer food products far in excess of usual high production.

The human element in production was never more prominent than at the present moment. Notwithstanding this fact, it is true that the human element in industry has had less constructive consideration at the hands of the American manufacturer and business man than other elements that enter into any given product. We took good care of our machine tools, cutting tools and other equipment, also selected carefully the materials that go to make up our product, but the help question was one of hiring and firing. It took the Great War to wake up the American manufacturer and business man to the problem of the human element in production. The hiring and firing program soon disappeared; the Government came along and said, "Stop using human effort on non-essentials; if you use human effort at all, use it on essentials such as we will assign to your plant." A great many workmen were taken out of their former positions and transferred to the shipyards, the munitions plants and other war material producing plants. Rates of wages were paid that established an entirely new standard among us. Production was recognized by additional money rewards, the hours of labor were strictly limited and great emphasis was laid on the conditions and surroundings under which men worked, stressing the fact that men were men and must be treated as such; not to be looked upon as a commodity to be dealt in for profit but as the one fundamentally essential element in industry, the human element, with strong emphasis on the human. This brought a stream of gold and a glow of self-respect to the American workman and his family, which have lifted him out of the conditions under which he toiled formerly to a plane of life where he and his family secure more of the necessities and comforts of life than he was able to secure formerly, a higher plane of life from which he will never recede to his former position in the community. Many are the dangers and many are the benefits accruing to him and the community that surround him in this new place. But he is there and he will stay there, and those of us who use the human element in industry must recognize this and lay our future plans accordingly, and it was with this point in mind that this paper was written. A better title perhaps might have been The American Workman in His New Position in Society and His Relation to Production.

PRODUCTION MUST EXCEED CONSUMPTION

The need of increased production, no thoughtful man will question in this day when consumption exceeds production in many of the essentials as well as the comforts of life. The raising of wages without securing greater production can but result in the increasing of prices; the end of that program can lead only to very serious results. This has been recognized by several of the crafts among organized labor, as well as a strong demand that the profiteer in food, clothing and shelter be treated as a criminal. If all the profiteers in essentials were eliminated, which should be brought about at once, nevertheless much of the problem would still remain, until the American workman sees that the only permanently effective way to reduce prices is to have production equal and exceed consumption in any given commodity, it being understood that all profiteers will be kept properly jailed. When production exceeds consumption, then and not until then will prices come down and necessities and comforts be available to all. Let it not be overlooked that the American workman in his new and higher plane of life has created new markets which will consume vastly greater quantities of product than ever before, and the only way to meet this demand of the American workman is to produce more per hour worked.

This is the very heart of the problem and should be squarely met and handled. How can we get greater production per man-hour worked? This can be done and is being done in some of our plants. To make clear the various points concerned, illustrations will be drawn from facts and figures realized in one of these plants. We cannot at this time overlook the fact that certain fundamental laws and principles govern in the successful handling of the human element in production. We must recognize that the element is human; not mechanical or animal, but human. It is a conspicuous fact that the human phase of handling men and women in industry has been sadly neglected. Altogether too frequently labor has been looked upon as a commodity to be dealt with at will.

The day is here when the worker in the shops is no longer classed with the equipment of the institution, but associated with the human beings who constitute the board of directors and the owners of the business to whom the directors are responsible. The humanity of the human element in industry is rapidly being recognized by wide-awake management. From the employment man at the gate, who interviews those applying for work, down through the general superintendent to the smallest "straw boss" in the shops, the word has been passed along by the management that every employe, no matter what his or her place may be in the organization, must be treated first as a human being and then as an employe. In other words, the human element is the most important element in the business. The deal between the employe and the company must be absolutely square and above-board. He can sit down with the em-

[1]Vice-president and works manager, Cleveland Tractor Co., Cleveland.

ployment manager and discuss any phase of his relation in the plant or his family needs or anything else that concerns the common interests of himself and the company. The employment manager shall function fully as the only final link between the workman and the management. Wages, grievances, condition of work, bosses, or anything else along this line may be brought up, and when so brought up must receive attention. The workman has become a partner in the business and continues as such as long as he is employed.

We have heard much of late about labor desiring a part in the management of business, but I am convinced that all that labor wants along this line is a chance to say what should or should not be done as touching his immediate relation to the business. He does not want to shoulder the responsibilities of finance or sales, but he does want to help manage the conditions under which he works, the material and equipment that concern his job and the wages he receives, and in these he is well qualified to function. This foundation is essential to the building of the superstructure of increased production per man-hour worked. The human element in industry is preeminently human, and must be handled from that viewpoint. This element is possessed of mental capacity which must be reckoned with and should be carefully guided and used. It has been well said that the mental attitude of the worker toward the company is even more important than his physical skill in his work.

We now have before us this human element, which has not only a strong body but also a human heart and mind, a man. In this man, as truly as in any other, mind controls matter. Therefore, if we are to increase production with him, let us see to it that we get him thinking right. To get him thinking right we must ourselves think right. Let us here ask, "Why are we here considering the subject of increased production? Why was it that the recent session of the Chamber of Commerce of the United States held at Atlantic City was based wholly on the subject of increased production? Why does anyone want increased production?" We answer by referring to the reasons previously given, "The waste of war made it necessary," and "To reduce prices." Very good, but what in the last analysis is the answer to, "Why do we want increased production?" "In order that the financial returns to us may be increased and that thereby we may secure more of the necessities and comforts of life, and possibly also some of the luxuries." That is true, and it is equally true of the workman in the offices and shops of our plants, and only to the extent that we are able to bring this about for him will he respond. This is the underlying motive principle which must be applied; otherwise continued increased production per hour worked cannot be realized.

The workman must be paid in the ratio of production secured from him, and that without endangering his future. That is, he wants to know that the permanency of his job is not affected by his increased production. These two things well installed in his mind, namely, that he will profit in the ratio of his production and that his job will last, will cause him to respond permanently. This is an assertion based on experience of one and one-half years without any indication that the peak of the curve has been reached, the results being greatly increased earnings by the worker without any increase in the cost to the company per unit. How is it done? In reply I use here only the records and experience in the plant mentioned of the direct producers as distinguished from the indirect workers; that is, including the records of the machine operatives and assemblers, but not of the stock men, sweepers, inspectors, etc. Permit me to point out that I do not claim that this is the only way in which these principles can be applied; doubtless there are other schemes that will work as well and perhaps better. Neither do I claim that the present plan is a perfected article, but it has accomplished the results.

How One Plant Solved the Problem

At the close of the war this plant found itself with a labor condition that was anything but desirable, but on a par with most other metal-working plants throughout this country. Wages per hour were high as compared with the prewar basis and production per hour worked was very low. The mental attitude toward the company was not constructive for quick rehabilitation after the war. While prices for the necessities of life were forcing the worker to ask repeatedly for higher wages, the resulting turnover of labor was very high, all of which was becoming evident in the cost of the product. The problem was how to enable the worker to meet the ever-increasing cost of living by permitting him to earn more money, and at the same time not increase, and if possible reduce, the cost of each unit produced. Both things were satisfactorily realized.

After several months of conferences with superintendents, foremen and workers, it was decided to adopt a differential scale of wage payment based on production. In this plan all machine and assembly jobs were to be divided into about ten classes, each of these to be on a certain hourly base-rate of pay. The simpler jobs were put into the classes paying the lower base-rates, and the more highly skilled operations into the classes paying the higher base-rates per hour. Each base-rate per hour was the current rate paid in the community for the respective jobs. Each operation was carefully time-studied by practical men who function as standardization men and they with the foremen and the superintendents, and at times the operator of the machine, decided on what constituted 100 per cent efficiency. When this was decided and agreed on, the operative was expected to reach within two weeks this 100 per cent efficiency in production for the hourly base-rate paid him. For every 1 per cent additional production over 100 per cent he was paid ⅔ per cent on his hourly rate and this was accumulated over his total production for the pay period. The elements entering into production were recognized as (*a*) the equipment with which the operative worked, including machine and cutting tools, jigs, fixtures, etc.; (*b*) the materials on which he worked and which enter into the product; (*c*) the conditions under which he worked, in respect to light, heat, ventilation, hours of work, dining room, service, etc.; and (*d*) the man himself. These four elements were recognized as the factors of production. The company, through its indirect organization, assumed the first three, the equipment, the materials and the working conditions, holding the worker responsible only for the fourth element, the man himself. All four elements must be kept up to standard to demand standard performance from the operative.

A daily report was compiled showing the efficiency of each worker in each department, based on the elapsed time according to calculagraph records and a count of pieces finished. This report was ready at nine o'clock each morning for the day preceding, having been made up by night-clerks. All operatives who were less than 100 per cent efficient were recorded in red; all others, 100 per cent and over, in black. An efficiency crew was organized under the toolroom superintendent, whose business it is to investigate each case below 100 per cent and

report to the general superintendent which of the four elements caused the low efficiency. It is the duty of the general superintendent to see that the cause is removed. If it was equipment, he put the master mechanic on the job; if it was bad material, he put the material supervisor on the job; if it was a bad condition, he saw that it was removed, making sure that the first three elements were in the standard condition before the man himself was blamed for the low efficiency. If it was found to be the man himself, he was helped, taught how to do the work, but if he continued to fail, he was either put on another job or let out. The latter, however, was done only after repeated trial and opportunity. It was understood, however, that nothing under 100 per cent would be satisfactory. It was fully understood also that no matter what efficiency a man made, his rate would not be cut as long as the job continued.

Should the tooling be changed and the time-study accordingly changed, the operative must make at least 10 per cent more than he did under the old method, providing the gain is at least 10 per cent to the company by the new tooling. Assemblies and sub-assemblies are time-studied in groups and the efficiency of the group is the efficiency of each member of the group, whatever class he may be in. The plant works the 44-hr. week. All overtime is paid on the basis of time and one-half on the hourly base-rate only.

The results have demonstrated the success of the plan for both the workman and the company, because the earnings of the men have been greatly increased, while the cost per unit produced has not increased. One and one-half years ago the average efficiency, according to a given standard of 100 per cent, was between 62 and 65 per cent. The average efficiency for the same work during the month of April, 1920, was 145 per cent. The earnings of the men increased from 46 cents per hr. in January, 1919, to 71 cents on May 15, 1920, or 52 per cent. In the same period the cost per unit involving the same operations of labor was reduced 17.3 per cent. In other words, the benefits accrued to both the workman and the company because of the increased production per man-hour worked. The number of hours required to do the work was greatly reduced, as shown by the fact that the number of men on the payroll at the beginning was 15½ men per unit produced, and on May 1, 1920, 8½ men per unit produced.

The question will probably be asked immediately, "What of the quality of the work?" Careful records have been kept and the results of the last five months will indicate the tendency.

Months	Cost of Defective Workmanship on Basis of Total Material and Labor Costs, per cent	Average Relative Efficiency, per cent
January	1.140	130
February	0.644	130
March	0.822	135
April	0.763	145
May	0.685	150

These figures are correct within two points. Therefore, the conclusion is that earnings by the men have gone up 52 per cent, costs have been slightly reduced and the quality of the product has been enhanced.

The human element in production, if properly directed by the management, will cooperate by increasing production to the profit of both the employer and the employe.

PREVENTION OF AUTOMOBILE ACCIDENTS

WITH the assistance of the National Safety Council the Underwriters Laboratories is carrying out an extensive series of experiments with appliances designed to prevent automobile accidents. Tests are being conducted on the use of laminated glass for wind-shield construction, wind-shield cleaning appliances, steering-gear construction and head-lamp dimmers and diffusers. The use of laminated glass for wind-shield construction is a comparatively new feature in automobile practice. It can be readily seen that injuries through collisions will be materially decreased if the flying glass hazard is reduced. The application of wind-shield cleaners to automobiles also works toward a reduction of collision accidents.

In testing the steering-gears a set is mounted upon a stand and operated for a number of times considered equivalent to what would be expected in this respect with an automobile during five years of severe service. In this way it is expected that definite data on the possibility of accidents occurring from defective construction will be secured.

While these tests with mechanical sources of automobile accidents and their prevention are being conducted the National Safety Council through its local organizations is making a study of all traffic accidents. The report of the Central Mississippi Valley Division covering traffic accidents in the city of St. Louis for the month of March and their causes gives the information presented in the accompanying table.

Street accidents of all kinds	791
Automobile accidents	494
Fatalities from automobile accidents	11
Persons injured in automobile accidents	187
Persons injured in motorcycle accidents	111
Persons injured in street-car accidents	44
Persons injured in bicycle accidents	15
Persons injured in horse-drawn vehicle accidents	7
Careless driving	205
Causes not determined	190
Skidding	91
Unavoidable accidents	81
"Jay walking"	27
Mechanical defects in automobiles	20
Backing automobile without giving signal	11

An automobile traffic signal installed on an automobile and designed so as to indicate the intentions of the driver with respect to stopping or turning will in the opinion of the Laboratories effect a further reduction in the number of collisions. For several years this form of signal has been undergoing tests not only on the road to show its suitability for use and effect upon the drivers of following vehicles but also to determine whether such signals possess sufficient durability to last for the life of the vehicle on which they are installed. Five or six of these signals have been tested. It is stated that the main trouble with them appears to be lack of sufficient durability. In some cases where electric traffic signals have been employed, a marked increase of the fire hazard to the automobiles to which they were attached, was, it is claimed, observable, due to defective wiring and methods of installation.

Kerosene as a Tractor Fuel

By JOHN A. SECOR[1] (*Non-Member*)

MID-WEST SECTION PAPER *Illustrated with* CHART

KEROSENE has advanced to the front rank as a fuel for the farm tractor within a decade. Of twenty-eight tractors tested at the North Dakota State demonstration in 1918, only five used gasoline. At the Ohio State University tests held at Columbus in January, 1919, seventeen of the twenty-one tractors used kerosene. At the Ohio State field tests in July and August, 1919, fifty-six tractors were tested and forty-eight of these operated on kerosene. Sixteen tractors were tested under the direction of Professor Aitkenhead of Purdue University, at Evansville, Ind., in the summer of 1919, and fourteen used kerosene. In January, 1920, thirty-three tractors were tested at Ohio State University and twenty-eight used kerosene. According to lists issued by farm periodicals, a heavily preponderating majority of tractors burn kerosene.

Everyone knows that the oil-burning tractor has arrived. Yet as recently as the beginning of the present century, the throttle-governed oil engine ranked relatively lowest among commercial power generators. Oil engines, like hot-air engines, were classed as auxiliary powers. All these early oil engines were equipped with some form of oil vaporizer, for it was assumed that the problem of burning oil in an internal-combustion engine could be solved only by devising a suitable vaporizer. The oil was usually injected into the vaporizer under pressure, and ignition was produced by the residual heat of combustion, augmented by the heat of compression. Electric ignition also was tried in several instances without attaining commercial success.

The early oil engines were decidedly inferior to the gas engine in respect to greater production costs and general performance. They required more frequent cleaning, due to the carbonization and incomplete combustion of the oil fuel. The kerosene engine, which won the first prize at the Pan-American Exhibition held at Buffalo was partly disassembled every morning to remove the carbon deposited during the previous day's operation. Furthermore, oil engines were characterized by low fuel efficiency; because they could not operate under compressions which were perfectly feasible for gas or for gasoline engines. None of the early oil engines was equal to the throttle-governed gas engine in respect to fuel-mixture regulation, when operating under a fluctuating load. The best results were obtained when their working conditions remained constant, with variables practically excluded, as in the kerosene lamp. Test conditions, therefore, combined constant load, speed, proportions of fuel mixture, internal temperature, compression and hit-and-miss governing. One of the best oil engines of this type, the Crossley of England, developed 1 b.-hp.-hr. per 0.82 lb. of kerosene under constant conditions at rated load, which was a remarkable performance for that early date. In a word, the oil engine at that time had not attained the flexibility under variable load conditions which is one of the most valuable characteristics of the gasoline engine. Sir Dugald Clerk refers[2] to the typical oil engine of that date as follows:

> The oil engine is not so economical from a heat engine point of view as the gas engine; that is, the oil engine so far, for a given number of heat units intrusted to it as oil, does not convert so large a proportion of those heat units into indicated work as a gas engine
>
> The difficulties which prevent immediate improvement in economy are to be found in all cases in the methods of vaporizing. A further difficulty occurs in connection with governing the engine

Some oil engines at that time, notably the Priestman, employed the throttle-governor, but these were characterized by excessive fuel consumption at light loads. In these, as noted by Clerk,

> The proportion of oil and air admitted is kept as nearly as possible constant, but the compression is reduced. This method is by no means an economical one and results in a heavy consumption of oil even at light loads. The engine used almost as much oil without load as at full load; in fact, in Unwin's test there was no difference in oil consumption between half power and no load at all. For many years, the difficulty of using safe oil and producing compressed explosive mixtures from it was so great that no effective oil was placed upon the market. Even now the oil engine is a much more tricky machine than the gas engine.

From 1870 to 1900 a large number of kerosene engines were produced. In each case it was hoped that the detracting features of the oil-burning engine had been obviated. One of these, the Brayton oil engine, was exhibited in 1876 at the Centennial Exhibition in Philadelphia. Several of these different oil engines, such as the Brayton engine and the Campbell engine of England, were the product of the highest engineering skill then available in America and England, and were financed by ample capital. In each of these instances, it was stated, over $500,000 had been expended without attaining commercial success.

None of the early types of oil engine was adapted for, or used, in the farm tractor. As recently as 1900 the steam tractor practically monopolized the field of power farming; but the supremacy of steam power was soon challenged by the gas tractor and within recent years the gas tractor has commanded a much broader market than the steam tractor. Shortly after the gas tractor had demonstrated its marketability, tentative attempts were made to adapt the farm tractor to the use of kerosene instead of gasoline, the advantages of kerosene being its lower cost per gallon and its greater heating value per unit volume. Both kerosene and gasoline were much lower in price ten years ago than at present. Also the chain of fractional boiling temperatures of common engine gasoline was much lower at that time than at present.

The first kerosene engines for farm tractors embodied gasoline-engine practice in respect to the throttling gov-

[1]Consulting engineer, Advance-Rumely Co., La Porte, Ind.
[2]The Gas and Oil Engine, sixth edition, 1896.

ernor, and time has demonstrated that this is the most flexible and satisfactory method of speed control. Among the obvious limitations of some of the earlier kerosene tractors was inability to operate the engine on kerosene if the tractor was stopped. Tractors of this kind had to shift from kerosene to gasoline when idling. Also, some kerosene tractors were inferior to gasoline tractors when subjected to a constantly changing load, such as occurs in threshing. These tractors frequently used gasoline, or sometimes, when driving a separator, a mixture of gasoline and kerosene.

Due to excessive fuel consumption, some of the earlier kerosene tractors lost the advantage of the lower price of kerosene. Some tractors used from 1¼ to 1¾ lb. of kerosene per b.-hp.-hr. At the Official State Tractor Demonstration held at Minot, N. D., in June, 1918, there were several instances in which the cost of fuel per acre plowed was the same for gasoline and for kerosene tractors. The average quantity of fuel used at Minot by twenty-three kerosene tractors was 3.77 gal. per acre, costing 66.77 cents. For five gasoline tractors the average was 3.26 gal. per acre, costing 88.20 cents; but the highest efficiency was shown by a kerosene tractor using 2.97 gal. per acre, costing 45.00 cents. In January, 1920, at the State tractor tests held at Columbus, Ohio, one gasoline tractor used 0.673 lb. of gasoline costing 2.81 cents per b.-hp.-hr., but there were several kerosene tractors which had a fuel cost of 2.90 cents per b.-hp.-hr., gasoline costing 26 cents and kerosene 17 cents.

Kerosene Tractor-Engine Development

The first step in the development of an efficient kerosene tractor engine was to recognize certain differences in the characteristics of kerosene and gasoline. The conditions required for complete combustion are the same in principle for both fuels and, in fact, for all other fuels; but in practice a wider latitude in providing ideal conditions is permissible for gasoline than for kerosene. The commercial liquid fuels usable in internal-combustion engines can be divided into four classes. These would include (*a*) the alcohols, (*b*) the gasolines, (*c*) the common kerosenes and (*d*) the low-cost heavy-oil fuels, the last named comprising certain available crude oils, various distillates, "stove-tops" between 28 and 38 deg. Baumé gravity and some grades of fuel oil. In respect to heating value per pound of combustible the alcohols rank lowest. Ninety per cent alcohol has a heating value of 10,080 B.t.u. per lb. Gasoline of 58 deg. Baumé gravity has a heat value of 20,570 B.t.u. per lb. and 127,534 B.t.u. per gal. It weighs 6.20 lb. per gal. Ordinary kerosene of 43 deg. Baumé gravity has an average heat value of 19,970 B.t.u. per lb. and 134,597 B.t.u. per gal. It weighs 6.74 lb. per gal.

It would be difficult to name an average heat value for the usable crudes, distillates, fuel oils, and stove-tops. It can be stated as a fact, however, that large numbers of oil tractors are now using stove-tops successfully in Arizona, Arkansas, California, Montana and Washington. The stove-tops used vary from 28 to 38 deg. Baumé gravity. The heaviest of these oils has a heat value of 19,370 B.t.u. per lb. and 143,050 B.t.u. per gal. It weighs 7.38 lb. per gal. At present, under existing economic conditions, neither alcohol nor the fuel oils require consideration as available fuels for the tractor. But both these classes of combustible, including oils obtainable by distillation from shales, may at a later period prove impregnable bulwarks against future unlimited advances in the price of gasoline and kerosene. A recent investigation showed that, compared with the minerals production of 1870, the yearly output of coal had increased about sixfold, iron sevenfold, copper fourteenfold and petroleum seventy-fivefold. America is now producing more crude oil than at any previous period. The recent advances in all petroleum products are principally due to the decreased Mexican supply of crude oil. Statements such as the following appear frequently in the press:

> The State Department has been advised that the Mexican Government has stopped drilling by certain oil companies, alleging that they have not complied with the necessary requirements of the government
>
> In a recent interview Joaquin Santalella, chief of the Department of Petroleum, stated that the total number of oil wells in actual production in Mexico is 305, and that their total daily potential output is 1,995,223 bbl., or 728,256,395 bbl. annually. Only eighty of these wells were allowed to produce during the month of October, yielding 8,920,676 bbl., nearly all of which, both crude and refined, was exported. The present Mexican petroleum production is only one-seventh of the potential quantity which could be produced by existing wells
>
> Recent advances in crude have had the usual result of stimulating prospecting to an unusual extent. As an illustration, Imperial Oil Co. is making a thorough search for new oil fields in Canada, and is now planning to drill wells within the Arctic Circle. The location is 1400 miles north of Edmonton, Alberta, and 1200 miles from the nearest railroad. The drilling crew is now in winter quarters, and will start drilling as soon as the weather permits. Undoubtedly, the vigorous prospecting campaign in many fields will bring results.
>
> In the meantime it may be noted that oil engine conditions have changed. The problem of producing an acceptable oil-burning tractor has been solved. The oil engine is no longer inferior to the gasoline engine, but the oil tractor of the future must burn oil without waste. Manufacturer and user must unite in saving the oil.

Fuel Consumption

The average fuel consumption of seventeen kerosene tractors at the Ohio State tests in 1919 was 0.963 lb. of kerosene per b.-hp.-hr. and the average for four gasoline tractors was 0.951 lb. of gasoline. Six tractors used more than 1 lb. of fuel per b.-hp.-hr. It is gratifying to note the improvement in the 1920 Ohio State University tests over those of the previous year. Twenty-eight tractors this year showed an average consumption of 0.889 lb. per b.-hp.-hr. Prior to the present year, the record performance of an oil tractor was 0.7 lb. of kerosene per b.-hp.-hr. This was at Winnipeg, in 1912. The best record at Columbus in 1920 was 0.606 lb. of kerosene per b.-hp.-hr., which breaks the former Winnipeg record. Private tests of tractors of the same type have shown results as low as 0.55 lb. of kerosene per b.-hp.-hr.

Regarding the means by which these results were obtained, it is axiomatic that the thermal efficiency of an internal-combustion engine increases with an increase in its compression pressure. Furthermore, the compression of the charge results in an increase of the power per unit volume of piston displacement, and permits the use of lean gases, or leaner mixtures of rich gases which otherwise would be uninflammable. It is therefore advantageous to compress the charge to as high a pressure as is possible. The upper limit of compression is set by the ignition temperature of the explosive mixture used. The ignition temperature of the explosive mixture varies with the composition of the fuel and the strength of the mixture. The kerosene tractor of today need consume no more fuel than the gasoline tractor. In fact it should

use less, due to the greater heating value per gallon of kerosene.

The problem of using oil for fuel in the throttle-governed engine is complicated by the fact that the controlling factors of combustion become variables whenever there is a change in power or in engine speed. And the new conditions of temperature and compression created by each change of load are detrimental to efficient operation. Crude petroleum and its distillates are chemically complex mixtures of different substances. In respect to relative hydrogen and carbon content, gasoline and kerosene are nearly alike. Twelve samples of gasoline and four samples of kerosene showed the following average proportions:

Constituent Chemical Elements	Gasoline	Kerosene
Carbon, per cent	84.65	85.25
Hydrogen, per cent	14.84	14.37
Oxygen, per cent	.....	0.38

Kerosene has usually more carbon and slightly less hydrogen than gasoline. Nearly the same weight of air per pound is required in either case for complete combustion. In fact, some samples of gasoline and some samples of kerosene require theoretically the same weight of air for complete oxidation of the fuel. Although kerosene and gasoline contain nearly the same proportions of hydrogen and carbon, and although their potential heat values are nearly alike per pound of combustible, nevertheless they differ materially from each other in the molecular constitution of their respective component substances. Neither kerosene nor gasoline has a single definite boiling point. Each has a "chain," or series of boiling points, and the distillation temperatures of kerosene are much higher than for like fractions of gasoline.

The respective boiling points differ approximately as follows:

Boiling Points	Kerosene, deg. fahr.	Gasoline, deg. fahr.
Initial	305	Not over 140
20 per cent	410	Below 221
45 per cent	420	Below 275
90 per cent	500	Below 365
Dry Point	580	Not over 428

The boiling points named for kerosene are the results of distillation tests of tank-car samples from the Whiting refineries, which averaged 41.2 deg. Baumé gravity. As an index of quality it can be noted that all gravity tests are suggestive, rather than conclusive, although this applies particularly to present-day gasoline. The boiling points given for gasoline are quoted from the Navy Department specifications for engine gasoline, adopted Sept. 1, 1917, and later adopted by the Committee of Standardization of Petroleum Specifications,[3] Oct. 2, 1918.

Kerosene is further differentiated from gasoline, in that it is heavier, is comparatively non-volatile and has a higher viscosity coefficient. Its composition also differs from gasoline in being more diverse in respect to the nature and range of substances forming the mixture. Engineering authorities have for this reason assumed that the difficulties encountered in burning kerosene at higher loads are almost wholly attributed to the heterogeneous nature of the compounds composing kerosene, certain of these compounds being easily broken down to form others, and to free some of the carbon.

[3]This specification was printed in THE JOURNAL, December, 1918, p. 406.

Fuel Mixtures

Regarding ignitibility of fuel mixtures, rate of flame propagation, preignition and cracking, or decomposition of the fuel components, in throttle-governed engines, experience shows that internal temperature conditions which are suitable or permissible for gasoline are impracticable for kerosene. This is noticeable when an oil engine is operating under a minimum or a maximum load. At low loads the temperature must be higher than for gasoline and, on the contrary, high-load temperatures must be lower than for gasoline. Under all working conditions low-load temperatures must be hot enough to insure inflammation of the mixture. Bunsen defines the temperature of ignition as the lowest temperature capable of communicating to the constituent parts of a gaseous mixture the ability to combine abruptly. High-load temperatures, on the other hand, must be cool enough to prevent either preignition or cracking. Under the proper working conditions, the temperature curves of gasoline and kerosene engines of the same size may intersect at approximately two-thirds load. For many years physicists such as Davy, Bunsen and Sorel, have recognized the effects of compression and temperature on the fuel to air ratio. Sorel notes that

> Pressure, as well as temperature, plays a very important part in gaseous reactions, either directly or indirectly. Pressure directly accelerates the reactions. Variations of pressure have the same effect as variations of temperature. With a mixture of given composition, at a constant temperature but under a variable pressure, conditions of equilibrium would be met, next non-explosive reaction, then explosive reaction. Hence with weak mixtures combustion is likely to be very incomplete. This can be obviated by increasing the pressure more and more in proportion as the mixture is naturally less explosive. The limits of combustion depend upon the pressure, the temperature, and the variations to which a gaseous mixture is submitted, as well as on its initial composition, whether the mixture presents a state of apparent equilibrium or is the seat of non-explosive reaction, or is explosive.

The quality, quantity, compression and temperature of fuel mixtures are controlling factors in the operation of all gas engines. But in throttle-governed oil engines the regulation of all these factors in coordination demands greater consideration than is necessary for ordinary gasoline or gas engines. This is due to the complex character of kerosene and the effects of extreme variations of compression and temperature on kerosene fuel mixtures, which occur within the power range between idling and full load in a variable-compression engine. The proportions of kerosene mixtures and the internal temperature must be adapted to each degree of compression. Inasmuch as the variations in compression are normal and unavoidable in a throttle-governed engine, the temperature and the fuel-to-air ratio should be correspondingly varied to suit each new set of conditions created by the changing compressions which occur under a variable load. Temperatures rise or fall with the compressions; but not in accordance with the heat requirements of the complex oil fuel. The lighter fractions of kerosene determine the minimum heat of ignition demanded by an oil engine operating under low-load compressions. In a gasoline engine, under high-load conditions, we have a combination of relatively high compression and high temperatures which would be impracticable in an oil engine. For, like conditions cause preignition of kerosene mixtures. This can be avoided, obviously, by reducing the compression, thereby sacrificing thermo-

dynamic efficiency. But such reduction of compression is quite unnecessary. If variation of pressure has the same effect as variation of temperature, we can retain fuel efficiency and avoid both preignition and cracking at the higher loads by lowering the temperature of the combustion chamber and fuel charge, and simultaneously reducing the relative proportions of kerosene in the fuel mixtures.

Since compression is both a controllng factor and a variable, the ratio of fuel to air and the temperature within the combustion chamber must be correspondingly varied in correlation as already shown, so as to maintain the proper working relations between proportions, temperatures and compressions for oil fuel at all loads. Furthermore, in an oil engine subject to frequent changes of load, the regulation of internal temperatures and fuel mixture proportions must be absolutely automatic. The most skilful operator could not possibly readjust temperatures and fuel mixture proportions in an oil tractor driving a separator. Dynamometer records show that abrupt, though momentary, fluctuations of drawbar pull occur even in plowing.

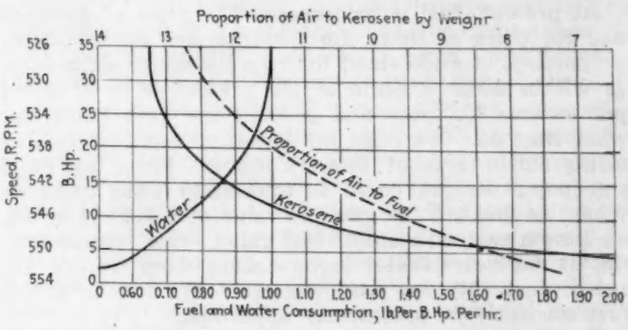
The regulation of power, speed, fuel mixture proportions and internal temperatures, in automatic coordination with varying compressions, involves an obvious increase in the functions of the throttling governor. To satisfy the required conditions the governor must simultaneously regulate, in due correlation, the quantity and proportions of the mixture and the internal temperature, thereby automatically coordinating the regulation of the working conditions at all loads within the capacity of the engine. When subject to such automatic coordinate control, kerosene is more flexibly responsive to a varying load than gasoline.

Regulating Heat Conditions

Experience has demonstrated that water is an efficient and suitable medium for regulating heat conditions in a throttle-governed oil engine. Water can be used internally as well as in the water-jacket. For internal cooling, water can be inhaled with the fuel charge. Prof. C. F. Hirshfeld remarks that

> The use of water probably leads to a water-gas reaction with the hydrocarbons, or with some of the carbon liberated from those hydrocarbons, resulting in the formation of CO_2, CO and H_2O. This would prevent the deposition of some carbon, which would not otherwise be burned and would therefore result in a cleaner engine. These water-gas reactions start at a temperature of about 1000 deg. fahr. and are very active at a temperature of 1800 deg. fahr.; they cannot therefore occur to any extent during compression as has been assumed by some. The water serves as a diluent of the combustible mixture, just as any other gas or vapor would, and it thus decreases the rate of flame propagation and hence decreases the ultimate maximum pressure. Its action in this way would be particularly noticeable at the higher loads when the velocity of flame propagation in the undiluted mixture would reach its maximum value. It will be evident also that within limits the action of the water will be dependent upon its quantity. Too little will give all the troubles with which the engineer is familiar; too much will cause similar troubles. The proper quantity in any engine varies with the load, although not in direct proportion.

Both nitrogen and water are diluents. But nitrogen is an inert diluent, while water admitted in proper quantities may even serve as a fuel element, enriching the gas by the addition of hydrogen and oxygen. Hydrogen, within limitations, is a desirable constituent because it increases greatly the calorific value of the fuel and promotes flame propagation. Oxygen combines with carbon to form carbon monoxide or dioxide. It is essential, therefore, that the total quantity and relative proportion of water admitted be regulated by the governor to suit the varying internal temperature requirements incident to a varying load. There should be automatic regulation of water as well as fuel. No water whatever is required when starting, or when operating under low loads which require much higher temperatures than are necessary for gasoline engines. The internal temperatures at the lower loads are increased for kerosene by maintaining a higher temperature for the water-jacket than is required for gasoline engines. But at higher loads the temperature is reduced as required, by inhaling water and regulating the quantity of water so as to maintain consonance between internal temperature and compression. The quantity should increase more rapidly than the load increases, until it has attained its maximum value, in both actual quantity and relative proportion, at maximum load.


Proportion of Air to Kerosene by Weight
14 13 12 11 10 9 8 7
526 530 534 538 542 546 550 554
Speed, R.P.M.
35 30 25 20 15 10 5 0
B. Hp.
Proportion of Air to Fuel
Water
Kerosene
0 0.60 0.70 0.80 0.90 1.00 1.10 1.20 1.30 1.40 1.50 1.60 1.70 1.80 1.90 2.00
Fuel and Water Consumption, lb. Per B. Hp. Per hr.

Curves Obtained from a Test of a Tractor Engine Burning Kerosene

The art of burning kerosene, or even heavier oils, is comprehended in that all controlling factors of combustion, including the proportions of the fuel mixture and its temperature at the time of ignition and during the working stroke, must always be kept in physical correlation with the density of the air. And when the compression is variable, the other controlling factors also must be varied in coordination with the compression, so as to maintain efficient working relations between compressions, proportions and temperatures during a varying load. Thorough mechanical admixture of fuel, air and water is essential in using kerosene. At one time Otto entertained the fallacy that there are advantages in a stratified fuel mixture, but later observation taught him that each molecule of combustible should be in intimate contact with the air required for its oxidation. Experience has proved that it is perfectly feasible to apply these principles of automatic coordinate regulation to the kerosene tractor, and the results of such regulation are now matters of public record. Fifty years have elapsed since the first abortive attempts to use kerosene for power. Today kerosene has become the chief fuel for developing power for the greatest of all human tasks, pulverizing the soil of the earth once yearly to produce the world's food.

The Discussion

H. L. Horning:—It has been known for some time that the location of the spark-plug in the cylinder and the shape of the cylinder walls make a great difference. Recently we obtained a combustion-chamber shape with which quiet running could be maintained when using

kerosene. We have reached the important conclusion that no combustion chamber should have any surfaces parallel to opposing surfaces. The spark-plug should not be opposite a flat surface.

Flame propagation is one of the things that must be controlled. Most of what Mr. Secor has said applies to flame-propagation control. It is a sudden changing in velocity of the molecules, or chemical action, that causes the sound called "ping" and makes it necessary to reduce compression, thus sacrificing its thermodynamic advantages. Since 1915, through the work of Mr. Kettering and other Society members, we have learned more about flame propagation. The burning of fuels requires an understanding of the scientific facts underlying the phenomena of combustion. We must deal intelligently with the true nature of matter, forgetting commercial consideration for awhile, and eventually solve these problems.

At present, fuel is too cheap. The price of kerosene and the price of shoes, for instance, are out of proper proportion. I understand that the leather in some shoes is within about 3 cents of the present price of silver per ounce. Kerosene and gasoline are very cheap for what they do. We must not think of fuel in terms of money but in terms of the work it does. From that basic standpoint we can begin to appreciate what price is. When we find out the gasoline value of a loaf of bread, we have a real estimate of fuel value. Our responsibilities as engineers center in how much work we can get out of fuel. We are very wasteful. We fail to utilize fuel efficiently in present-day apparatus.

We have found out only recently that we should run the intake charge through the valves at a rate of 160 ft. per sec. for real economy. Do we know, for instance, that there is a relationship between the areas of the intake passages that will give the greatest economy, a definite step from one point to another? We never realized before that an engine works under conditions that are really absurd because of slight mechanical distortions; that, for example, the valves are not doing the work they should do under full load. In some recent experiments we were able to keep the valves and valve seats accurate to form and so attained about 20 per cent better economy. These are methods to which we must resort to avoid excessive fuel prices. To conserve fuel, we must do what they are doing in Europe, where fuel is high. They make real mileage on a gallon of gasoline in England and France.

Gasoline is the sunshine of past ages and food is the sunshine of the present. There is a fundamental difference between the two. The former is a capital resource and the latter is a constant product. The great problem, then, is what we can do after we use up our fuel capital. We will be forced to store energy of some kind for subsequent utilization and if we wish to continue the rapid progress we are making, which it is expected will result in there being 10,000,000 to 13,000,000 automobile vehicles in this country within the next two years, we must conserve fuel in every way possible and be conversant with the fine points that the Europeans are considering so carefully. The petroleum and the automotive industries are intensely interested and will soon make some reassuring announcement in regard to fuel, but they will ask us to conserve it to the utmost by utilizing the principles which Mr. Secor has enumerated.

J. E. POGUE:—The engineers of the American automotive industry, in studying the fuel problem, should follow closely what is happening in Europe, especially in England. The situation there is much further advanced than in this country. The fuel shortage abroad is a most effective force making for technological advance. In studying the fuel problem in this country, much more attention has been devoted to effectively utilizing kerosene than to making use of the heavier petroleum cuts, such as gas oil and fuel oil. Practically one-half of our crude petroleum is now converted into fuel oil, and this material will undoubtedly represent one of the most promising sources of engine fuel, once it can be effectively used. If the automotive engine can be gradually adapted to the use of fuel progressively lower in volatility, the refiner will be able to add much more rapidly to the supply of engine fuel than if the present rigid requirements on the part of the engine are maintained.

The fuel problem is not so much a problem of ultimate shortage or of price; it is a problem of coordinating two entirely diverse developments, the supply of fuel and the engine type. The supply of fuel has been changing and will continue to change in quantity and character; the change is dependent partly upon the course of engine evolution. The fuel and the engine type, each mutually interdependent, have been allowed to seek adjustment through trial and error. It is now becoming evident that this method is costly and wasteful, and too liable to result in a maladjustment leading to fuel shortage, to be depended upon. The problem is to coordinate engine and fuel according to a predetermined plan which will result in maximum service from both fuel and engine. This problem is exceedingly complicated, because it will require a type of reasoning and a method of work which have not been necessary in the industrial and engineering fields of the past. With the stress of circumstances urging us on, however, both the petroleum and the automotive industries can be expected to take redoubled steps to clear away the only cloud on the horizon of automotive transportation. We have no hope that the cloud will disappear entirely; in fact, we do not want it to disappear, because, if it does, we will relax our efforts. On the other hand, no one should underestimate the difficulty of keeping this cloud where it belongs, on the horizon.

MR. HORNING:—Has Mr. Secor ever used CO_2 or the products of combustion as a diluent in the process? In England, they eliminate the water from the diluent and introduce the remaining CO_2 and nitrogen into the entering fuel mixture, which retards the combustion and causes the flame to travel more slowly.

JOHN A. SECOR:—Work has been done along that line with some success in this country. I have not made experiments in this connection.

MR. HORNING:—We have made the experiment and it controlled the knocking very well, but we have nothing ready for the market. They are doing that in England. Some of the best British tanks ran on kerosene entirely, during the war; they used the products of combustion to retard the flame propagation and obtained very good results. That is advantageous, because the substances needed for use are continually being made. It is slightly better than introducing aniline, alcohol or benzol.

MR. SECOR:—Some twelve or fifteen years ago, a man conducted experiments along that line at Chicago. He sent me the results and, as he explained them, they were encouraging. Personally, I have never substituted CO_2 for water.

Regarding alcohol and the fuel oils, I consider that neither is a commercial fuel at present. I have looked upon alcohol as an alternative fuel. The significant thing

(*Concluded on page* 156)

Constitutional Amendment Discussion at the Summer Meeting

IN accordance with the provisions of C56 of the Constitution of the Society the four amendments which were proposed at the Annual Meeting held at New York City, Jan. 7, 1920, were brought up for discussion at the business session of the Semi-Annual Meeting which was held on the evening of June 21 at Ottawa Beach, Mich. These amendments which relate to the changes in the age for election to member grade, the amount of the dues to be paid by the junior members, the wording of the paragraph relating to the composition of the Council, and the method of vacating elective offices were printed in the April issue of THE JOURNAL, together with the discussion at the Annual Meeting and written discussion that was subsequently submitted and the report of the Constitution Committee.

THE DISCUSSION

PRESIDENT J. G. VINCENT:—I will ask Vice-President Wall to discuss the constitutional amendments proposed at the meeting of the Society in January. This matter is much more involved than might appear on the surface. It has been the basis of considerable discussion, and Mr. Wall will endeavor to clarify the points as quickly as possible.

W. G. WALL:—The Constitution Committee and the Council do not favor a change in the age at which applicants can be elected full members. We believe that many are qualified for such membership at the age of twenty-six. The membership qualifying age of the American Society of Mechanical Engineers is, I understand, thirty-two, but we believe that the age of twenty-six is sufficient in our industry in many instances. The amendment proposed in January is as follows: "Member grade shall be composed of persons thirty-two years of age or over." We think that the age should remain twenty-six.

In regard to Junior membership, the proposed amendment was that Junior grade should be composed of persons who at the time of election are under thirty-two years of age. After due consideration the Constitution Committee thought that thirty years was better, and in this the Council agrees. In that view the amendment in this respect would be changed to read thirty years. Under the present Constitution a Junior member may be transferred to Associate or Member grade at the age of twenty-six, and must be so transferred at the age of thirty. The amendment proposed in January was to the effect that a Junior member could not be transferred to Associate or Member grade until he had reached the age of thirty-two. It is the opinion of the Council that the present provisions of the Constitution as to the age at which Juniors may or shall be transferred should not be changed.

The next amendment proposed in January was that the dues of a Junior should be increased from $5 to $15 at the age of twenty-eight. The dues are now $5 flat. The Constitution Committee was not in favor of the proposed increase at the age of twenty-eight. The Council, after considering the matter this afternoon, felt that the dues for Junior grade should be raised to $10 flat from the time of election.

Another proposed amendment was ineligibility for election to the Council except in the case of those who had been members of the Society for two years and demonstrated their willingness and fitness. The Constitution now reads, "The affairs of the Society shall be managed by a board of fifteen directors chosen from among its Members or Honorary Members, which shall be styled 'the Council.'" The Council does not believe that that amendment proposed is necessary. The Nominating Committees have the matters indicated in mind. The fewer changes we make in our Constitution the better, I believe.

Regarding the five Second Vice-presidents, the present Constitution provides that these shall represent motor-car, aviation, tractor, marine and stationary internal-combustion engineering respectively. The constitutional amendment proposed was that they should preferably be chosen to represent these fields of engineering respectively, but that when men of suitable standing, experience and proved desire to serve the Society were not, in the opinion of the Nominating Committee, available from each respective field, two or more from other fields should be chosen. We think that would complicate the matter. There is no reason why good men should not be available in each of the fields. The Council believes that the Constitution should remain unchanged in this connection.

The last change proposed was in regard to vacating elective offices of the Society. The amendment submitted was that "The Council shall declare any elective office vacant in case its incumbent is absent from four successive meetings, or other failure to perform the duties of his office, unless by unanimous vote of the other members of the Council such action is deemed as not being in the best interests of the Society." I think the Council can take care of that matter without any constitutional change. In the first place, a man will not be nominated or elected to the Council unless there is proper assurance that he will fulfill his obligations. The present Constitution provides for the vacating of elective offices for failure to perform duties for six months. We believe that is all that is necessary.

H. W. ALDEN:—I move that the first proposed amendment mentioned by Mr. Wall, referring to the age at which applicants can be elected to full Member grade, be rejected. [The motion was seconded and carried unanimously.]

F. E. MOSKOVICS:—I move that the proposed amendment with regard to election of Junior members be amended to read that Junior grade shall be composed of persons who at the time of election are under thirty years of age. [The motion was seconded and carried unanimously.]

B. B. BACHMAN:—I move that the amendment just amended be submitted by letter ballot to all members entitled to vote. [The motion was seconded and carried unanimously.]

W. A. BRUSH:—I move that we vote down the amendment in which it is proposed to change the provisions of

the present Constitution in respect to the ages at which a Junior member may or must be transferred to Associate or Member grade. [The motion was seconded and carried unanimously.]

C. M. MANLY:—I move that the proposed amendment in the matter of the amount of the annual dues of Junior grade of membership be amended to provide that these shall be $10, regardless of the age of the Junior member. [The motion was seconded and carried unanimously.]

MR. MOSKOVICS:—I move that the amended amendment with regard to annual dues of Junior members be submitted by letter ballot to all members entitled to vote. [The motion was seconded and carried unanimously.]

W. C. KEYS:—I move that the proposed amendments to C29 and C34, referring to eligibility to election to the Council, the election of Second Vice-presidents, and the vacating of elective offices, be voted down. [The motion was seconded and carried unanimously.]

ALCOHOL MINOR FACTOR IN FUEL FIELD

J. L. LEWIS, petroleum technologist of the Bureau of Mines, recently wrote a letter in which he pointed out that alcohol and other substitutes derived from vegetable matter could be only a minor factor in the fuel situation for an indeterminate period to come and that, while there are immense quantities of waste vegetable matter throughout the country, this is widely scattered and in only a few places concentrated sufficiently to make it feasible to manufacture alcohol from it in competition with gasoline. Mr. Lewis also pointed out that it is mechanically impossible to use straight alcohol as fuel in an engine developed to operate on gasoline, and that alcohol to be available as fuel must therefore be blended with gasoline. Alcohol will not blend with gasoline except in the presence of a considerable quantity of benzol or some similar product. Even with alcohol available, he points out, it would be necessary to produce large quantities of benzol from coal to blend with the alcohol and make it an interchangeable fuel with gasoline.

Production of benzol for 1920 he estimates at 95,000,000 gal., about 2 per cent of the total gasoline supply for the year. Even were alcohol available at prices which allowed its use as internal-combustion engine fuel, Mr. Lewis observes the output of benzol or similar by-products from coke ovens would have to be increased greatly to allow the use of alcohol in sufficient quantities to add materially to the fuel supply. At present, he said, a comparatively small quantity of alcohol produced from sugar refinery wastes is being placed on the market in competition with gasoline. This is being sold as alcohol, benzol, ether and gasoline blends.

REFINERY EFFICIENCY REAL SOLUTION

Mr. Lewis' object was to point out what he believes to be the real solution of the problem; the working out of more efficient methods for taking petroleum from the ground and for transforming it into fuel. In connection with the development of commercially feasible cracking processes to allow the breaking up of a greater proportion of the residuum now selling as fuel oil for burning under boilers into suitable internal-combustion engine fuel he stated that there is at present only one largely used cracking process, the Burton process, which will operate only on one quality of oil, that constitutes a small proportion of the heavier oils produced in this country. He believes that from 40 to 50 per cent of the petroleum products now being used in a most inefficient manner for steam raising should be made available for manufacture into synthetic gasoline by the development of commercially practical cracking processes, which would double the quantity of gasoline obtainable from our present production of crude.

Mr. Lewis said: "Processes have been developed in recent years for producing synthetic gasoline from the heavier and less volatile portions of the crude oils, from which processes some 15 per cent of the 4,000,000,000 gal. of gasoline produced in 1919 was derived. Synthetic gasoline can be manufactured also from oil shales and gasoline substitutes are being manufactured from by-product coke ovens, and can be made by low-temperature destructive distillation of coals and lignites. I am strongly of the opinion that the problem of obtaining greater supplies of gasoline will be solved primarily by obtaining supplies from mineral matter. It is a fact not commonly known even in the oil industry, that the wells obtain but a small proportion of the oil which exists in the sands and that probably not more than from 10 to 20 per cent is commonly extracted. Oil is found in sands and sandstones in pores which are almost microscopic in size. When the gas which forces this oil out of the pores of the sands is exhausted the remaining oil is held like water in a sponge and the well ceases to yield oil in commercial quantities although a larger part of the 80 to 90 per cent of the oil remaining can be obtained by the proper methods.

GREATER YIELD FROM SANDS

Some exceedingly promising methods have been in use for a number of years, which have proved undisputably that much more oil can be obtained from our oil sands, but there are numerous important problems which will call for the best scientific and technical research for their solution before a full measure of our oil supplies can be obtained. At the present time the Burton cracking process is held under patent by the Standard Oil Co. of Indiana. The discovery of a process available to all refiners might readily double the quantity of gasoline obtainable from our present production of crude oil and defer any apprehension of a gasoline shortage for many years to come.

Everything should be done to encourage and foster the benzol industry. Still larger quantities of gasoline substitutes can be made by retorting the coals and lignites which are now being consumed as they come from the mines. If the available oils could be extracted from every ton of coal and lignite before it was consumed, the supply of internal combustion-engine fuel would be greatly increased.

It will be practically necessary that any substitute for gasoline as an engine fuel be practically interchangeable with gasoline. Alcohol will not blend with gasoline unless there is a considerable quantity of benzol or a similar product in the mixture. Therefore, unless some other solution of this problem is found it will be necessary to produce large quantities of benzol from coal to blend the alcohol with gasoline and make it an interchangeable fuel.

WASTE MATERIAL SCATTERED

Were it possible to gather the refuse from the farms and from the lumber camps and other places, a tremendous quantity of alcohol could be obtained. From a quantitative standpoint, petroleum, coal and oil shale are likely to be the cheapest raw material for making gasoline substitutes.

I suggest that serious consideration be given to encourage the development of gasoline and gasoline substitutes (*a*) by increasing the recovery of oil from our oil fields; (*b*) by developing processes for making synthetic gasoline out of heavy oils; (*c*) by encouraging the development of processes for making gasoline and gasoline substitutes out of oil shales, coals, lignites, peats and (*d*) by developing processes for making alcohols, ethers, etc., from waste vegetable matter.—*National Petroleum News.*

Notes on the Use of Heavy Fuel in Automotive Engines

By H. M. Crane [1] (*Member*)

Semi-Annual Meeting Paper

I WILL begin my remarks by stating that we cannot expect to get the results in operation with the present type of motor-car gasoline that were easily possible with the gasoline marketed fifteen years ago. I believe that you all recognize this to be a fact, and I speak of it simply to emphasize the necessity of bringing continual pressure to bear on the manufacturers of fuel, with the idea of forcing them, as far as possible, to improve the suitability of the fuel for use in automotive engines. There is a tendency at the present time to blame the automotive engineers for all our difficulties with fuel, when what blame there is should certainly be shared by the manufacturers of the fuel who have undoubtedly made great strides in increasing the quantity produced but have done so at the expense of the quality and without making any serious effort to improve the quality by the mixture of other materials with the petroleum distillate. We must admit that there are many engines in use today, and that some are even now being marketed, which are entirely incapable of making good use of the fuels that must be used in them, and that with better design this need not be the case. On the other hand, we are face to face with the necessity of accepting engines having inferior performance because of the nature of present-day fuel, or of adopting complications in the methods of fuel supply that will generally be beyond the skill and intelligence of the average engine operator to care for.

Probably all of you will agree with me in this statement of the situation. If there are any who do not, some simple comparative tests will quickly convince them that I am right. Just pick out the best car you can think of, equipped with all the latest contrivances in carbureters, hot-spots, electric heaters, etc., and compare its operation, when run on commercial gasoline, with its operation when run on gasoline having an end-point of 300 deg. fahr. If this is not convincing, remove the various bug-killers and repeat the test with the light gasoline.

We tested many Hispano-Suiza engines during the war and for much of that period used commercial motor-car gasoline for fuel. We had little difficulty in getting full power and good economy with this fuel, but we were dealing with an engine run at practically full load and constant speed. The distribution in these engines was extremely good at the normal speed of operation, while acceleration and full-load operation at low speeds did not have to be considered at all. In spite of these facts we finally concluded that it would be more economical to use a better grade of fuel for testing purposes; we had been gradually reducing the oil consumption and began to have trouble in getting the engines run-in without scoring the cylinders; what little oil there was on the walls was being washed off by the unvaporized fuel. The saving of fuel, due to the shorter time required for running-in, and the saving in scored cylinders, practically equalized the higher fuel price.

Viewed superficially such statements as I have just made may seem to be entirely futile at the present time, and it might be said that we are now facing a condition that no amount of regret for a situation that is past will ameliorate. I do not believe that any such opinion would be well founded. Before the solution of a problem can be undertaken with a reasonable hope of success, that problem must be studied from every possible angle and its real nature determined with approximate certainty. The results that experience has shown are easily obtainable in the very simplest forms of automotive engine when using a fuel that is volatile at fairly low temperatures must certainly be considered in working out the automotive fuel policy of the future.

Fuels of Different Grades

Perhaps my point of view on this matter will be clearer if I put before you several of the alternatives as they appear in the light of present knowledge. With the use of a fuel having a volatility suitable for the regular operating temperatures of engines working on the Otto cycle, we can use an engine of great simplicity, both in its main components and in its various accessories. Not only will it be simple in construction, but also in operation under all climatic conditions. It will be economical in the use of fuel and lubricating oil under widely varying conditions of load and speed. These features will naturally be coupled with an excellent all-around performance in full-load power at all speeds and in rapidity of acceleration. Do not forget that the past tremendous growth of the automotive industry has been largely due to the gasoline engine being the simplest primary source of power.

With fuel of the type now being furnished commercially, we have an entirely different picture. We have not yet changed the main components of engine design to any great extent, although there are more and more engineers who believe that if this fuel is to be handled with any degree of economy it will be necessary to make fundamental changes in engine design and to adopt the Diesel or some similar type. What has been done so far, except in marine and stationary work, has been to attempt to make up for the deficient volatility of the fuel by improvements in carbureters and manifolds and by applications of heat, with the object of possibly getting a dry gas into the cylinders. Great progress has undoubtedly been made in these directions, but we are still a long way from a really satisfactory result. This is especially true in the case of automobile engines where a high degree of flexibility is essential and where, due to varying climatic conditions, a very wide range of operating temperatures must be expected and provided for. Part of this progress has been the result of detail

[1] Consulting engineer, New York City.

improvement in design of carbureters and manifolds and in the application of heat and has not required any considerable increase in complication. With the simple changes, however, we have not been able to obtain the all-around performance or the economy in the use of fuel and lubricating oil that are easily obtainable where a more suitable fuel is available.

The satisfactory use of the present type of fuel varies to a great degree, depending on the range of service required of the engine and its general design. The single-cylinder engine of the lighting plant, running at a constant speed and at a fairly steady load, performs very well even on kerosene. On the other hand, the multi-cylinder engine of the passenger car is badly handicapped because of the very wide range in both speed and load which must be taken care of to give satisfactory operation.

Design Requirements to Secure Good Results

I have no intention of writing a long essay on design but will describe briefly the principles that should be followed to get as good results as possible with heavy fuel in the conventional type of motor-car engine with a view to getting the best all-around performance. In the first place, I do not agree with some engineers as to what constitutes good performance. In my opinion, experience has not demonstrated the high-speed engine to be either economical in operation or desirable in other ways. You may think that in saying this I am departing from my subject but this is not the case. The valve-timing required to bring the peak of the power curve above 2500 r.p.m., using any reasonable valve areas, is bound to make use of a considerably delayed closing of the inlet valve. In my experience this never fails to interfere seriously with the distribution in multi-cylinder engines at speed below 1000 r.p.m. I believe that F. H. Trego called attention to this fact in a recent paper.

There is no question in my mind that the best possible distribution is the only proper foundation on which to build in the handling of heavy fuel. This is because all the elements required for vaporization are present in the cylinder to a greater extent than in any other part of the system. There is a relatively long period of time during the suction and the compression strokes for vaporization to take place and there is a large amount of heat present on the cylinder walls and especially on the head of the piston to assist in this action. It is for this reason that single-cylinder engines are able to handle heavy fuel much more easily than engines of the multi-cylinder type of design.

I will begin therefore by saying that the valve-timing should be laid out so as to assist correct distribution as far as possible, especially at the lower engine speeds. I will assume that the carbureter used is capable of correct metering, not because this is usually the case, but because the metering has no particular bearing on this discussion. Even if the metering be correct, it is highly desirable that the design of the carbureter be such that the fuel is broken up as finely as possible and thoroughly mixed with the incoming air. There are certainly many carbureters on the market today in which this is not done. In engines of moderate speed there is no difficulty in using a high enough air speed through the carbureter to go a long way in this direction.

Now comes the problem of taking the column of air and fuel spray and dividing it uniformly among the different cylinders. When it is remembered that the column of air and spray is frequently accompanied by a stream of liquid flowing along the walls of the inlet pipe, this might be thought to be an impossible proposition. As a matter of fact this can be done with a surprising degree of success if the inlet manifold is properly designed. The first important principle in manifold design is in my experience that there should be a steady up-grade from the carbureter to the inlet valves. In fact, I would always design an engine so that this would be the case. This arrangement is desirable so that the flow of liquid in the manifold shall be controlled as far as possible by the airstream. With a down-hill manifold the liquid will flow toward the engine under the influence of gravity whose force is in no way related to the demands of the case. It is almost indispensable that the flow should be uphill at least until the manifold has branched to the various cylinders.

On multi-cylinder engines, especially of the six-cylinder type, it is very desirable to have as compact a manifold as possible. A long manifold is certain to set up periodic pulsations at various engine speeds, which will always upset the distribution. Furthermore, a long manifold will usually make an engine hard to start and logy on the pickup. Of course it is wise to make the manifold of the smallest diameter consistent with the required maximum engine power. As to the best shape for the manifold, this must be worked out for each particular engine. On six-cylinder engines I think that good results can always be expected from what I call the candelabra type of manifold. In this type the engine is divided into two sets of three cylinders each and there is a branch lead from the carbureter to each set. Each branch divides into three others of as nearly equal length as possible, one to each cylinder. A plain manifold reaching across all the cylinders with the carbureter attached to a tee at the center will frequently give good results. I have emphasized the desirability of good distribution because the final requirement in handling heavy fuel of low volatility is heat and the less of this that needs to be used the better. High temperatures cut down the volumetric efficiency and seriously interfere with the satisfactory use of alcohol as an antifreeze. The principle of the so-called "hot-spot" is excellent but is not always well carried out. It is frequently applied at the top of a tee or on the outside of a bend. The liquid does not usually collect at these points except at fairly high engine speeds. At low speeds the liquid tends to separate out of the airstream and will be generally found at the inside of bends and turns. This is because of the weight and viscosity of the liquid which causes it to seek the shortest path to the cylinders. There are also manifold designs which are considerably distorted to get the "hot-spot," with the result that the distribution is not as good as it should be. In such cases more heat is required than would otherwise be necessary.

Methods of Generating the Involute Spline and Its Application

By Douglas T. Hamilton[1] (*Member*) *Illustrated with* Drawings

THE spline is a development of the single key, and is generally understood to refer to a member which is provided with a series of keys. Formerly splines were made with straight sides and were produced by the forming process. A new development consists in applying the involute curve to the sides of the spline. While a spline cannot be considered exactly as a gear tooth, because of the different functions it performs, it can, nevertheless, be generated in the same manner as an ordinary gear tooth when provided with involute curves.

The multiple spline has obvious advantages over the single key, but it will be of interest to mention briefly wherein an increased number of splines is superior to a smaller number. The square shaft, which was the progenitor of the splined shaft, has several disadvantages. It is difficult to obtain a good fit between the two parts, absolute concentricity is almost impossible of attainment and it has a much greater tendency to burst the shell. The use of involute curves for the sides of splines, instead of having them straight-sided, is a still further improvement. There are several reasons why the involute-sided spline is better than one having straight sides. The involute spline can be generated with a tool which does not change its shape when resharpened; hence, greater accuracy, with its attendant possibilities for interchangeability, can be attained. Further, due to the curved inclination of the sides of the spline, especially on a splined shaft upon which sliding gears are held, there is a tendency for the gears always to remain concentric with the shaft when under load. This is not true to the same extent with the straight-sided spline; consequently, much closer fits between diameters are necessary than is the case with an involute spline. It is also a well-known fact that a generating tool used for cutting gear teeth does not necessarily have the same shape as the tooth it produces. Further, with the generating principle, the tooth thickness can be varied without changing the involute shape, simply by feeding the generating tool in farther or holding it back. This flexibility is not possible with the forming process. The involute spline can be generated just as accurately as a gear tooth and, as will be explained, has other advantages.

Forming Splines

Fig. 1 shows one way of forming a spline on a shaft. Here the forming cutter is shaped so as to cut a series of slots, thus forming splines with straight sides radial with the center. The accuracy of this method is dependent upon the accuracy of the cutter itself and the accuracy of the indexing mechanism used in spacing. This form of cutter, especially when of the eccentric-relieved type, cannot be ground satisfactorily after hardening. Its accuracy cannot therefore be assured; hence, this process of cutting splines is not under absolute control.

Fig. 2 shows the generating principle applied to the production of straight-sided splines. This method can be depended upon to give greater accuracy than that shown in Fig. 1, but the cutter, while it can be ground by the forming process, cannot be generated; hence,

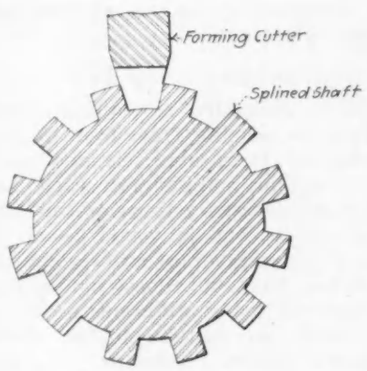


Fig. 1—Using a Forming Cutter

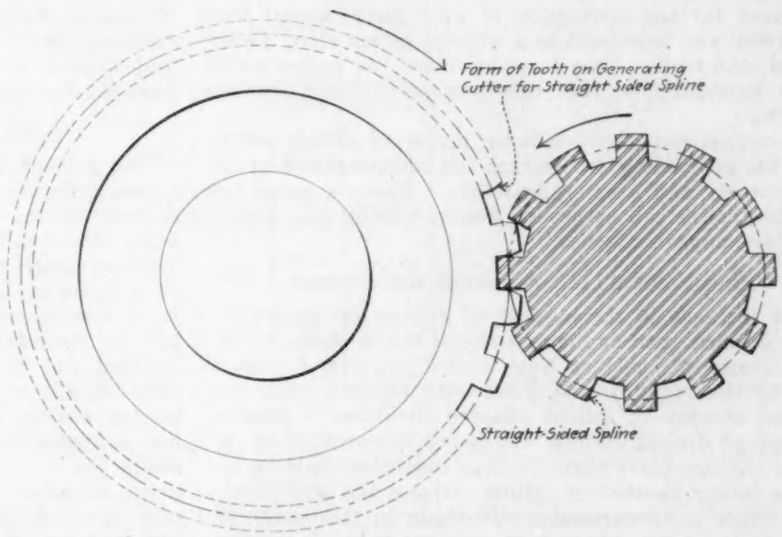


Fig. 2—Applying the Generating Principle to Produce Straight-Side Splines

Two Ways of Producing Splines on a Shaft

[1]Advertising manager, Fellows Gear Shaper Co., Springfield, Vt.

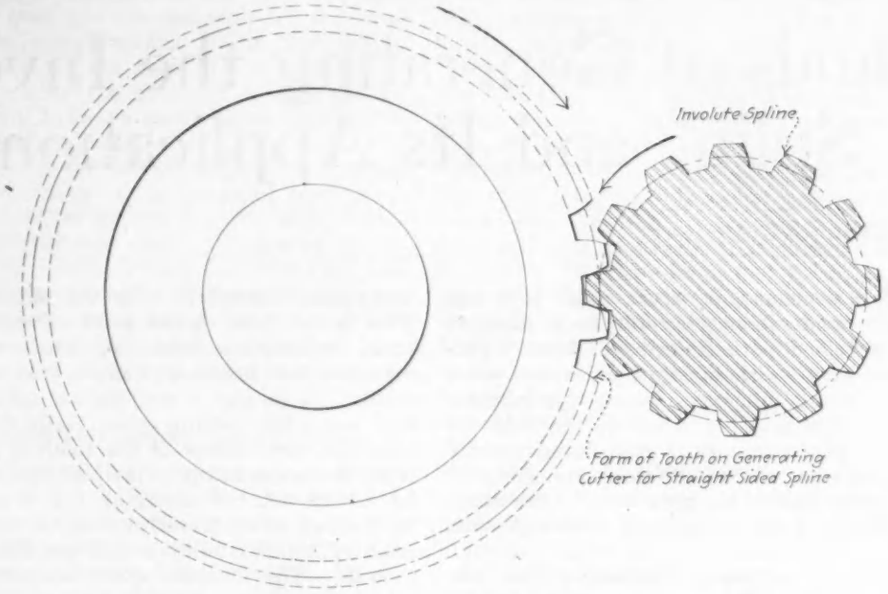


FIG. 3—PRODUCING INVOLUTE-SIDE SPLINES BY THE GENERATING PRINCIPLE

this process also is not under absolute control.

Fig. 3 shows the generating principle applied to the formation of splines having involute sides. The cutter has all the characteristics of a regular generating cutter used for the production of gear teeth, except that the teeth are "stubbed" to a greater extent than the so-called stub-tooth. This form of cutter can be generated after hardening, so that this process is under absolute control.

A comparison of these three processes plainly shows that the generating process has the advantages of greater accuracy and greater flexibility. Hence a generated involute spline can be produced economically on a strictly interchangeable basis.

PRESENT S. A. E. STANDARDS FOR SPLINES

The increase in the number of splines for spline fittings decided upon at the meeting of the S. A. E. Standards Committee held at New York City, Jan. 6, was a step in the right direction for two reasons. The increased number of splines adopted furnishes a greater number of driving points, and hence a better drive between the two parts that are thus connected; and an increase in the number of splines reduces the wall thickness, which is of particular advantage in the design of airplane parts, as they can thus be made much lighter. But in all the present S. A. E. Standards the same number of splines is used for the various diameters, which seems to be not exactly what the requirements demand. It would apparently be much better to have the number of splines governed by the diameter. In other words, the number of splines should be greater as the diameter increases. This proposal has an advantage in the fact that the greater the diameter, as a general rule, the greater the torque the part is required to carry; consequently, a greater number of driving points is necessary. Two additional advantages are presented by the consequent reduction in wall thickness and the possibility of facilitating interchangeable manufacture.

The application of involute splines to shafts, couplings and clutches has been given considerable attention by the company which I represent. Proposed standards for these have been drawn up and are presented in Tables 1 to 3 inclusive. Regarding the use of the various forms of spline, Table 1 gives a list of splines which are intended to take the place of the twelve present S. A. E. Standards, Table 2 includes sizes for couplings and disk clutches not covered in the present S. A. E. Standards and Table 3 is for direct-drive clutches, another special case not standardized at present.

DESIGN OF SPLINES AND CLUTCH TEETH

The revised S. A. E. Standard for splines includes twelve different standards varying from four to sixteen splines in the ratios of four, six, ten and sixteen, with three different spline heights for each series. This evidently was found necessary to cover the variety of conditions to be met. But it would seem much more feasible to have the number of splines controlled by the diameter, rather than to choose an arbitrary number and then have so many different series. On very small work, such as couplings for electric-starter shafts, magneto shafts, oil-pumps, etc., where the diameter seldom if ever exceeds 2 in., and also where the wall is thin, it is desirable to use a comparatively fine-pitch spline. The same requirements are met with in the design of disk clutches, where a large number of teeth of comparatively fine pitch may be used. If the wall thickness of the outer member of the clutch is comparatively thin, which is generally the case, a coarse-pitch tooth is undesirable. For transmission, direct-drive and rear-axle shafts, a coarse-pitch spline is preferable. This makes another subdivision. We have proposed one standard for all spline work where a coarse-pitch spline can be used to advantage. For the sake of clearness, the divisions are placed in the following classes:

(1) Spline shafts, sliding under partial load or not sliding and having a drive or a push fit. All these conditions are met simply by varying the manufacturing tolerances. This can be accomplished with the same generating cutter by feeding it in further or holding it back as requirements demand

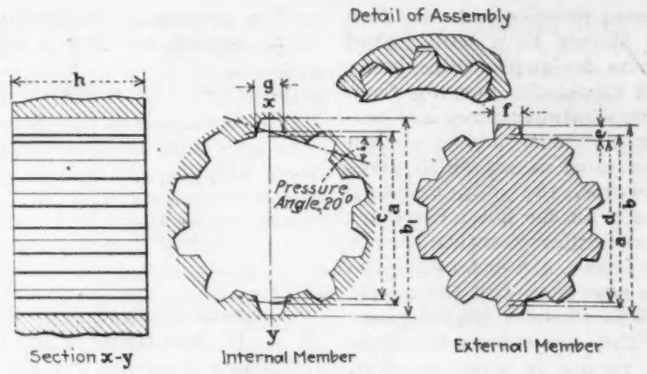


TABLE 1—PROPORTIONS FOR SPLINES

Nominal Diameter, in.	Number of Splines	Approximate Pitch	Dimensions in Inches								
			a	b	b	c	d	e	f[2]	g[2]	h
1⅛	10	9.803	1.020	1.125	1.156	0.9680 0.9670	0.9965 0.9955	0.079	0.1605 0.1600	0.1625 0.1620	3/4
1¼	10	8.823	1.134	1.250	1.285	1.0750 1.0740	1.0735 1.0725	0.088	0.1785 0.1780	0.1805 0.1800	7/8
1⅜	10	8.020	1.247	1.375	1.413	1.1840 1.1830	1.1825 1.1815	0.096	0.1960 0.1955	0.1980 0.1975	15/16
1½	10	7.352	1.360	1.500	1.542	1.2915 1.2900	1.2895 1.2880	0.105	0.2140 0.2135	0.2160 0.2155	1 1/16
1⅝	10	6.788	1.473	1.625	1.670	1.3985 1.3970	1.3965 1.3950	0.114	0.2320 0.2315	0.2340 0.2335	1 1/8
1¾	10	6.305	1.586	1.750	1.800	1.5055 1.5040	1.5035 1.5020	0.123	0.2495 0.2490	0.2515 0.2510	1 1/4
2	12	6.615	1.814	2.000	2.056	1.7220 1.7200	1.7195 1.7175	0.140	0.2380 0.2375	0.2400 0.2395	1 3/8
2¼	12	5.876	2.042	2.250	2.312	1.9400 1.9380	1.9375 1.9355	0.156	0.2680 0.2675	0.2700 0.2695	1 9/16
2½	12	5.277	2.274	2.500	2.568	2.1620 2.1600	2.1615 2.1595	0.170	0.2985 0.2975	0.3005 0.2995	1 3/4
3	14	5.072	2.760	3.000	3.072	2.6020 2.6000	2.5995 2.5975	0.200	0.3105 0.3095	0.3125 0.3115	2 1/16
3½	14	4.342	3.224	3.500	3.583	3.0420 3.0400	3.0395 3.0375	0.230	0.3630 0.3620	0.3660 0.3650	2 7/16
4	16	4.338	3.688	4.000	4.094	3.4820 3.4800	3.4795 3.4775	0.260	0.3630 0.3620	0.3660 0.3650	2 13/16
4½	16	3.837	4.170	4.500	4.600	3.9520 3.9500	3.9495 3.9475	0.275	0.4100 0.4090	0.4130 0.4120	3 1/8
5	18	3.879	4.640	5.000	5.108	4.4020 4.4000	4.3995 4.3975	0.300	0.4060 0.4050	0.4100 0.4090	3 1/2
5½	18	3.518	5.116	5.500	5.615	4.8620 4.8600	4.8595 4.8575	0.320	0.4475 0.4465	0.4515 0.4505	3 1/2
6	20	3.573	5.598	6.000	6.120	5.3320 5.3300	5.3295 5.3275	0.335	0.4405 0.4395	0.4445 0.4435	3 1/2

[2] Thickness on pitch circle, not chordal tooth thickness.

(2) Disk clutches, limited to slight movement
(3) Direct-drive clutches, sliding under partial load.

Under this class, covered in Table 1, the examples of work or conditions that can be met satisfactorily include spline shafts for automobiles, trucks, propeller-shafts, universal-joints, rear-axle shafts, sliding-gear shafts in machine-tool gearboxes and other speed-changing devices. In regard to spline shafts for use in auto-

mobile transmissions, the present practice is to use four or six splines, although ten splines have been looked upon lately with favor by some designers, these being made with straight sides and the shafts varying from 1¼ to 2 in. in diameter. These straight splines are produced by regular machining methods, and are then ground after hardening in the same cases, which gives fairly accurate results. However, the only grinding that can be done on the gears is in the hole; therefore it is necessary to provide considerable tolerance on the splines so that they can slide freely. In order that the members shall slide freely, the gear cannot fit too closely on the shaft and, where there is considerable tolerance between the splined members, they are subject to vibration when under load, which results in noisy gearing. The spline shaft is superior to the square shaft in this connection. Splines having involute sides provide more bearing surface and permit closer fits, thus presenting a further improvement.

The proposed manufacturing tolerance on the sides of the splines for Class 1 are as follows:

Tolerance, in.	Minimum Diameter, in.	Maximum Diameter, in.
0.0025	1⅛	2¼
0.0030	2½	3
0.0040	3½	4½
0.0050	5	5

A special application of the spline, not covered by the S. A. E. Standards, is for couplings and disk clutches. Couplings, especially for electric-starter shafts, etc., are of comparatively small diameter and, as a general rule, have thin walls necessitating fine-pitch teeth. The coupling really is an internal gear, the external member being a pinion. The conditions outlined here are

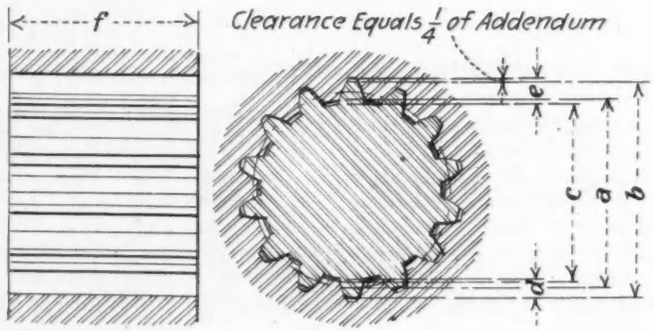


TABLE 2—PROPORTIONS FOR COUPLINGS AND DISK CLUTCHES OF THE INTERNAL-GEAR TYPE

Nominal Diameter, in.	Number of Teeth	Approximate Pitch	Dimensions in Inches					
			a	b	c	d	e	f
1⅛	14	14/18	1.000	1.111	0.972	0.083	0.083	¾
1¼	15	14/18	1.071	1.182	1.043	0.083	0.083	¾
1⅜	16	13/16	1.231	1.356	1.200	0.093	0.093	⅞
1½	17	13/16	1.308	1.433	1.277	0.093	0.093	⅞
1¾	19	12/14	1.583	1.726	1.548	0.161	0.107	1
2	20	11/14	1.818	1.961	1.782	0.161	0.107	1⅛
2¼	22	11/14	2.000	2.143	1.900	0.161	0.107	1⅛
2½	23	10/12	2.300	2.467	2.182	0.187	0.142	1⅜
2¾	25	10/12	2.500	2.667	2.382	0.187	0.142	1⅜
3	25	9/11	2.778	2.960	2.650	0.205	0.178	1⅝
3½	26	8/10	3.250	2.450	3.106	0.225	0.197	2
4	30	8/10	3.750	3.950	3.600	0.225	0.200	2
4½	34	8/10	4.250	4.450	4.096	0.225	0.202	2½
5	38	8/10	4.750	4.950	4.592	0.225	0.204	2½
5½	42	8/10	5.250	5.450	5.088	0.225	0.206	3
6	46	8/10	5.750	5.950	5.584	0.225	0.208	4
6½	50	8/10	6.250	6.450	6.082	0.225	0.209	4
7	54	8/10	6.750	6.950	6.580	0.225	0.210	4
7½	58	8/10	7.250	7.450	7.080	0.225	0.210	4
8	62	8/10	7.750	7.950	7.578	0.225	0.211	4½
8½	66	8/10	8.250	8.450	8.078	0.225	0.211	4½
9	70	8/10	8.750	8.950	8.576	0.225	0.212	4½
9½	74	8/10	9.250	9.450	9.072	0.225	0.214	4½
10	78	8/10	9.750	9.950	9.570	0.225	0.215	4½
10½	82	8/10	10.250	10.450	10.070	0.225	0.215	4½
11	86	8/10	10.750	10.950	10.570	0.225	0.215	4½
11½	90	8/10	11.250	11.450	11.070	0.225	0.215	4½
12	94	8/10	11.750	11.950	11.570	0.225	0.215	4½

true also with disk clutches, so that these two conditions can be included in one class. A disk clutch of the friction-disk type is generally made up of a considerable number of thin metal disks, between which a friction disk is used to form the frictional element. The teeth of disk clutches are generally made so that they have a comparatively easy fit to allow a free sliding movement and this tolerance can be obtained very easily by generating, simply by feeding the cutter in deeper or holding it back as the requirements demand.

The sizes run from ¾ up to and including 12 in. in diameter. Table 2 shows that an 8/10-pitch stub tooth is adopted for all sizes from 3½ up to and including 12 in. in diameter. For sizes from ¾ to 3 in. the pitch varies and the internal diameter of the internal member is enlarged to the base-circle diameter; from 3 to 12 in. the internal diameter is enlarged slightly beyond the standard inside diameters.

Another class of splines, which in reality are gear teeth, are those used for the direct-drive clutches in automobile transmissions and sometimes in machine-tool gearboxes. This spline standard is not included in the present S. A. E. Standards. In an automobile transmission the direct-drive pinion forms one member of the direct-drive clutch, and it also meshes with the constant-mesh gear on the countershaft. The internal member of the direct-drive clutch forms one of the sliding gears. In the diagram accompanying Table 3 a suggested method of making direct-drive clutches is given. This shows that the forward end of the pinion is reduced in diameter to prevent burring the teeth, which sometimes results from careless driving. This modification shortens the addendum below standard on the direct-drive pinion, simply making a shorter tooth on the clutching or forward end of the pinion. The reduction is made equal to the clearance of a standard stub tooth. The root diameter of the tooth in the internal member is also reduced to correspond.

This diagram also shows a proposed sliding-clutch gear, which appears to have several advantages. The drive for the gear from the splined shaft is directly in line with the external teeth, thus greatly reducing torsional strains, the clutching portion of the gear extends beyond the face of the external teeth and the rear portion of the hole is cylindrical, fitting the tops of the splines and giving additional support. This sliding gear will evidently run more concentrically than one not so supported.

In Table 3 the pitch is governed by the pitch of the

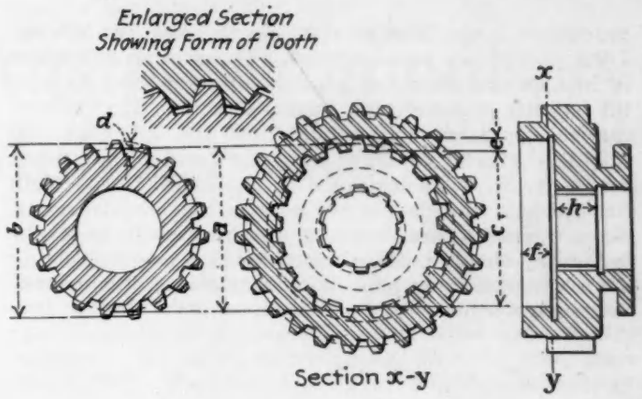


TABLE 3—PROPORTIONS FOR DIRECT-DRIVE CLUTCHES OF THE INTERNAL-GEAR TYPE

Approximate Nominal Diameter, in.	Number of Teeth	Pitch	Dimensions in Inches					
			a	b	c	d	e	f
2	12	7/9	1.714	1.881	1.611	0.222	0.163	3/8
2½	16	7/9	2.286	2.452	2.148	0.222	0.175	7/16
3	19	7/9	2.714	2.881	2.550	0.222	0.187	1/2
3½	23	7/9	3.286	3.452	3.088	0.222	0.203	9/16
4	23	6/8	3.833	4.021	3.602	0.250	0.213	5/8
4½	26	6/8	4.333	4.521	4.083	0.250	0.218	11/16
5	29	6/8	4.833	5.021	4.583	0.250	0.220	3/4
5½	32	6/8	5.333	5.521	5.083	0.250	0.222	3/4
6	35	6/8	5.833	6.021	5.583	0.250	0.225	3/4

Note: Dimension "h" corresponds to that indicated by the same letter in Table I.

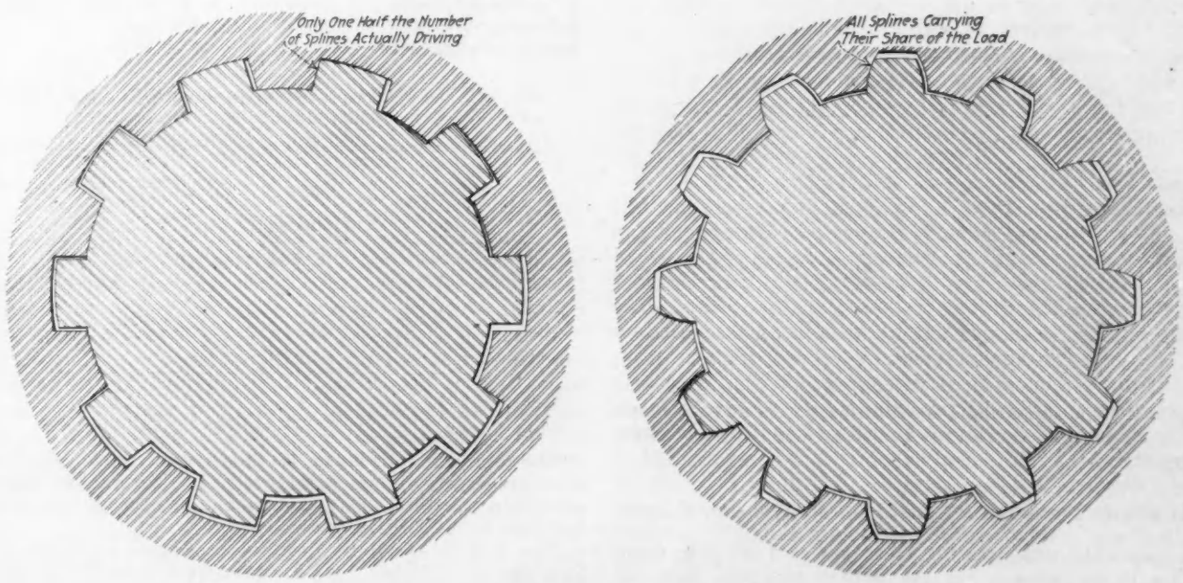


FIG. 4—A COMPARISON OF THE TWO TYPES OF SPLINE AS REGARDS CARRYING OF DRIVING LOAD

gears used in the transmission. In this case two pitches, 7/9 and 6/8, are recommended. There is no advantage in having this clutch of a pitch different from that of the regular transmission gears, although for internal clutches the pitch can be much finer and still have considerably greater strength than the teeth of the gears driven by it. The tolerance on the sides of the teeth for the last two classes are governed by requirements. These tolerances are, however, obtained easily in manufacture by simply feeding the cutter in deeper or holding it back, in the same manner as backlash is obtained between gear teeth.

The foregoing contains only a brief outline of the advantages of involute splines. Briefly summarized, they can be said to possess greater possibilities for securing interchangeability between parts; the involute can be generated much more accurately, because the tool used in producing it can be generated after hardening; the involute has a tendency to keep the parts concentric with each other and when used in an automobile transmission this would have the advantage of decreasing the noise of the gears. Further, the number of standards necessary to cover all conditions is considerably reduced, resulting in lower tool and manufacturing costs.

BRITISH TIRE STANDARDIZATION

THE urgent need for reducing the number of British pneumatic and solid tire sizes was recognized by the British Rubber Tire Manufacturers' Association in 1918 and a proposed schedule was subsequently presented to the Association in the same year. This was accorded strong support, and after a number of conferences the sectional committee of the British Rubber Tire Manufacturers' Association approved and submitted the report with some slight modifications, to the British Engineering Standards Association.

The British Engineering Standards Association issued the final report in April, 1920, in pamphlet form under the title British Standard List of Rubber Tires for British Standard Rims. Copies can be obtained through the Secretary of the British Engineering Standards Association, 28 Victoria Street, London, S. W. 1.

The report represents great progress in Anglo-American standardization. With the exception of the tire sizes adopted by the S. A. E. since the report was submitted, the American tire and rim standards agree with the British proposal.

Motorcycle Tires and Rims

A comparison of the British Engineering Standards Association and S. A. E. motorcycle tire sizes is given in the following table:

NOMINAL MOTORCYCLE TIRE SIZES

B. E. S. A.		S. A. E.	
Tire	Rim	Tire	Rim
24x2½	D 1		
26x2¼	BB		
26x2½	BB		
26x3	CC	26x3	CC
		27x3½	CC
28x3	CC	28x3	CC

As the CC rim dimensions for both countries are the same, it will be noted that the 26 by 3 and 28 by 3-in. tires are interchangeable.

Pneumatic Tires and Rims For Passenger Cars

The pnuematic-tire sizes for passenger cars for both countries are in accordance, but the British standard does not include the following tire sizes which with the exception of the 34 by 4½-in. oversize tire were adopted by the Society since the report was acted upon by the British Engineering Standards Association.

TIRE AND RIM SIZES NOT INCLUDED IN BRITISH ENGINEERING STANDARDS ASSOCIATION SCHEDULE

Tire	Corresponding Rim
33x4½	33x4½
34x4½	33x4
34x5	33x4½
34x5	34x5
36x6	34x5

The passenger-car pneumatic-tire rim dimensions adopted by the British Engineering Standards Association, with unimportant exceptions, conform with the present S. A. E. Standard.

Pneumatic Tires and Rims For Commercial Vehicles

The British commercial-vehicle pneumatic-tire sizes are in conformity with the present S. A. E. Standard, except the following tire and rim sizes which are not included in the British standard:

TIRE AND RIM SIZES NOT INCLUDED IN BRITISH ENGINEERING STANDARDS ASSOCIATION SCHEDULE

Tire	Corresponding Rim
38x7	36x6
40x8	38x7
42x9	40x8
44x10	44x10

Solid Tires

The inch sizes included in the British schedule of solid tires are in accordance with the S. A. E. Standard with the exception that the 36 by 3, 34 by 6 and 34 by 7-in. tires are not included in the British schedule.

The British standard includes schedules for cycle tires, light-car tires, metric sizes for pneumatic tires for passenger cars and metric solid-tire sizes. These schedules are intended mostly for domestic and Continental consumption.

Resolution Passed Against Compulsory Adoption of Metric System

THE "metric system" was scheduled for discussion at the business session of the Society held at Ottawa Beach, Mich., on the evening of June 21. It was stated by President Vincent that it had been thought by the officers of the Society that it would be well to have a short discussion of the subject inasmuch as much had been said recently in favor of and against adopting the metric system in this country, including the question whether it should be made compulsory.

In opening the discussion, C. R. Underhill expressed the belief that the way to adopt the metric system is to adopt it. He said, "If we had to figure out pounds, shillings and pence instead of our money in the decimal system we would all go crazy. It seems to me that a change to the metric system could not be made at once very easily, but that we could adopt it gradually. It would be a simple matter to follow metric units in design, using the conversion factors to obviate the necessity of making new tools. I think that if we should start the movement, employing our present gages, etc., and change over gradually, in the course of ten years or so we would find ourselves working with the metric system by preference."

W. C. Keys promptly moved that the Society go on record as being opposed to the compulsory adoption of the metric system. This motion, which brought forth much spontaneous applause, was seconded by Past-president H. W. Alden, and carried. The formal resolution on the subject, which had been approved by the Council of the Society, read as follows:

> Whereas, it has been represented to the public through the press and by other means that it would be desirable to have the metric system of weights and measures made compulsory in usage in the United States; and
>
> Whereas, it is the sense of the Society of Automotive Engineers, Inc., assembled in business session, that such action would subject the country to curtailment of production and to economic loss, therefore be it hereby
>
> Resolved, that the compulsory enforcing of the metric system of weights and measures as the legal standard of measurement is opposed by this Society as economically unsound and inimical to the best interests of the country

The Discussion

H. M. CRANE:—In the Standards Committee work, especially during the war, and in the matter of aeronautic standards at the present time, we are asked to take an international attitude. It does not seem to be worth while to discuss international standardization of a dimensional character in different units of measurement. The foundation of the whole proposition is different in different countries. In other words, I find as a member of the Standards Committee, that it is difficult to take any interest in international standardization unless we can talk the same language as the people on the other side. That is one phase of the matter.

The second phase is the widespread ignorance on the subject. It is the feeling of many that the adoption of the metric system would be a catastrophe and that they should assist in preventing its adoption. We went through that during the war. The only regret I have at this time is that we translated into English units the measurements of European designs to be made in this country. We used metric bolts, threads and gears throughout. The biggest mistake we made was translating the metric measurements into English.

One case arose which indicates difficulties in many people's minds that are really difficulties only in imagination. In designing a new gear pump we adopted metric sizes for the gears. Our shop sent the gears to be cut to Philadelphia, and the Philadelphia company said, "We have no cutters." Our shop, with some lack of imagination, said, "We cannot get metric cutters, so we will go to work and make them." They attempted to make the cutters for these gears with the lack of success one might expect. After losing nearly a month's time, someone thought of telegraphing to the Fellows Gear Shaper Co., and a metric cutter was sent to us by return mail.

E. S. GORRELL:—It may be of interest to the members to know that the question of whether the metric system should be adopted was raised before the International Convention on Air Navigation in Paris last summer. There were delegates present representing twenty-three countries. The body voted unanimously not to consider the question. The British and the American representatives were not in favor of adopting the metric system, the discussion of which the French and Italians wished us to take up.

H. W. ALDEN:—The question of compulsory adoption of the metric system in this country can be agitated to perhaps not an alarming extent but to the extent that it may become very embarrassing. We should take additional action to going on record at this meeting. I move that the Secretary of the Society be instructed to transmit to the committees of the Congress, of the House of Representatives and of the Senate, before which this question of the metric system adoption is up, the action which has been taken here tonight, so that these committees will know the feeling of this Society on the subject. [The motion was carried.]

A. D. T. LIBBY:—It can be seen readily why mechanical engineers are in favor of the English and not the metric system. On the other hand, those of us who have to do with electrical matters favor the metric system. I think that if the electrical engineers in this meeting were to vote on the question, they would all vote for the metric system, because all the electrical calculations are made in the centimeter-gram-second system; to apply these calculations at present in this country it is necessary to convert into English units. From the standpoint of the electrical engineer I prefer the metric system.

MR. ALDEN:—I would like to call Mr. Libby's attention to the fact that the resolution which has been passed here refers only to compulsory adoption of the metric system. That is altogether different from gradual adoption as conditions might make it seem wise. There is a strong tendency in the Congress today toward compulsory

adoption of the metric system, which would be a catastrophe.

MR. UNDERHILL:—I also wish to go on record as being opposed to compulsory adoption of the metric system, but I believe we should all bend our efforts toward changing over gradually to the metric system.

JOHN MCGEORGE:—I am strongly in favor of the metric system but not its compulsory adoption. I have found no difficulty whatever in designing and manufacturing new work dimensioned in metric units. There is grave objection to the compulsory manufacture of such things as screw threads according to the metric system.

MANPOWER ENGINEERING

THE application of manpower to production in its essence is the province of science to solve, just as much as the application of heat power and electric power to production was the province of science to solve. The general acceptance of this idea has been delayed by the usual fumbling in any new field. The efficiency engineer conceived of it in terms of saving lost motion. The industrial engineer conceived of it in terms of patchwork, a fixing up of industrial relations. The welfare man is a kind of compromise of the employer with his conscience who thinks something should be done but not too thoroughly. Scientific management was an imposition of theories; it was a juxtaposition of words without scientific basis or credence and was distrusted from the beginning. The trade union is a kind of armed camp from which men skirmish for advantage and position with little relation to the principles of production, and the employers' association is little better.

Long before the uniting principles in heat, power or electrical power were found, so much as man could discover and use was applied to increase production and to secure comforts. It was a long way from the discovery to the formulation of the science. There is similarly to be a long line of discoveries and of experiments in manpower, which parallel, though they are not identical with, those of other kinds of power. Marx believed the final answer to be Socialism. Lenine thinks he has found it in Communism. Gompers thinks it is in the trades unions. These are but passing movements which will eventually contribute their share to give the world a science of manpower.

The American inventive mind does not tolerate chaos and waste in other forms of power. The best minds and knowledge of engineering would be put to work in laboratories and shops to find a remedy for leaks in steam and electrical power. They would be the subject of scientific inquiry and of discussion. Not so with manpower. The subject is approached from the position of capital or of labor. Men's minds are impelled toward it to right wrongs or to earn rewards or to propound theories or to ride hobbies.

The problems of power are the same, whether it is to be extracted from men or from materials. How to get power units requires knowledge and organization. With manpower it is men; with heat and electricity it is materials. How to use power requiring management, how to increase power from existing units, requires research and experiment. Not so many years ago, the problems of electrical power and its application seemed not more difficult and variable than are those of manpower today. Scientists obtained the secret and put it to practical use and reduced their findings to engineering terms. Scientists will find the secret of manpower just as soon as they set about it in the spirit of attaining knowledge and its practical application. Why should not the Works Council or the bonus system or any other form of generator of power be subjected to as rigid tests as a new design of steam engine? Both are designed for one purpose, to increase production.

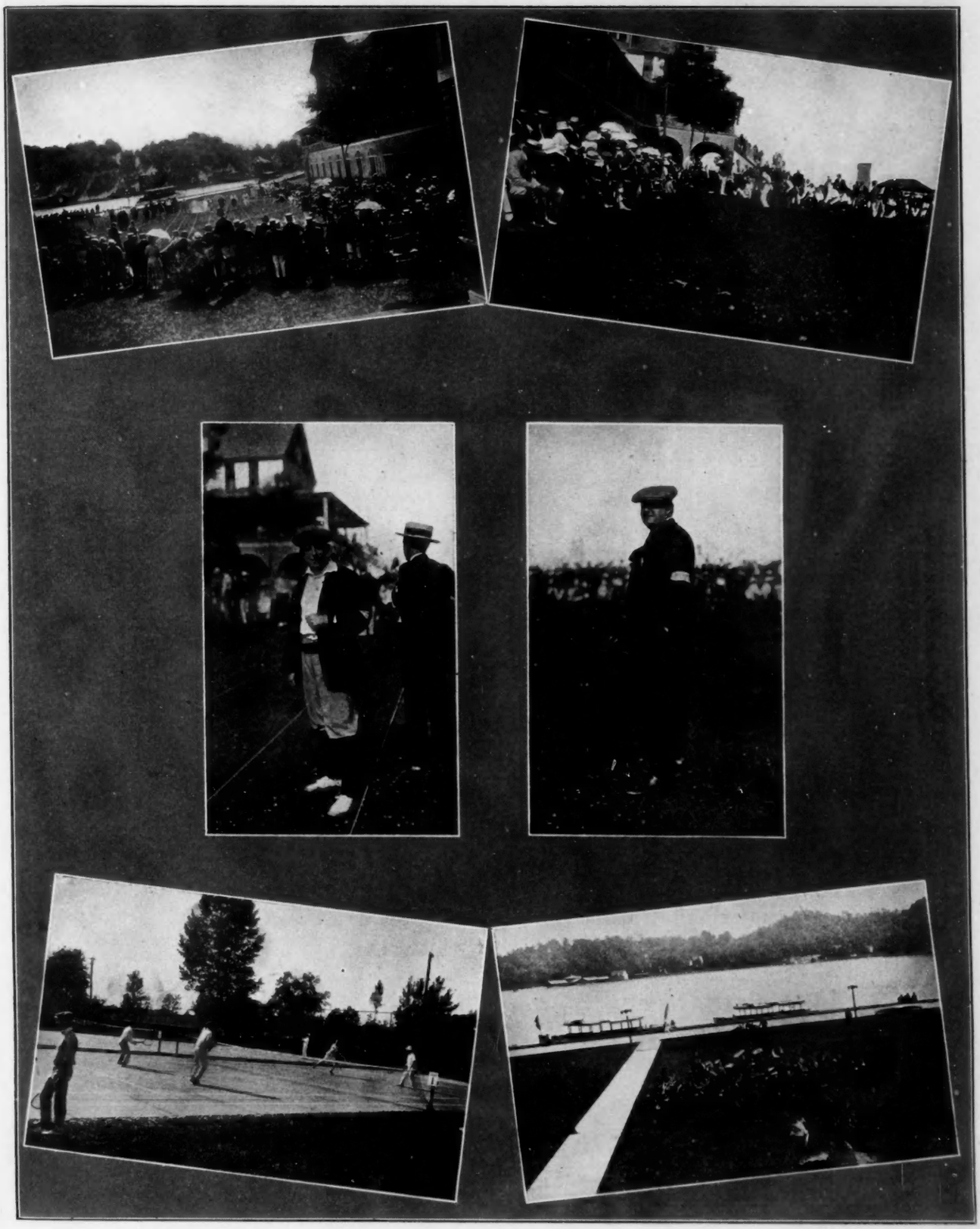
Once industrial leaders are convinced that manpower is an engineering job and that the efficiency of the present system of production depends largely upon the engineer, they will come together and begin to work out the fundamental principles and methods of operation and will begin to ask for trained men. The engineering colleges are awakening to the coming demand, but they, too, are doing patchwork and have not grasped the idea that the application of manpower to production is a science and that they can take a big lead in its formulation and ultimate operation. Most of the courses are still couched in terms of management rather than in terms of manpower. America senses but dimly as yet the demand that will be made upon its engineers for foreign countries. They will be called upon to handle manpower and to settle financial questions for which they have little preliminary training or basic judgment. American industries will be hard put to find substitutes for these men. The answer is the manpower engineer trained as thoroughly and as fast as American institutions can do it. The country that produces this kind of engineer will control the resources of the world.—Frances A. Kellor.

KEROSENE AS A TRACTOR FUEL

(*Concluded from page* 144)

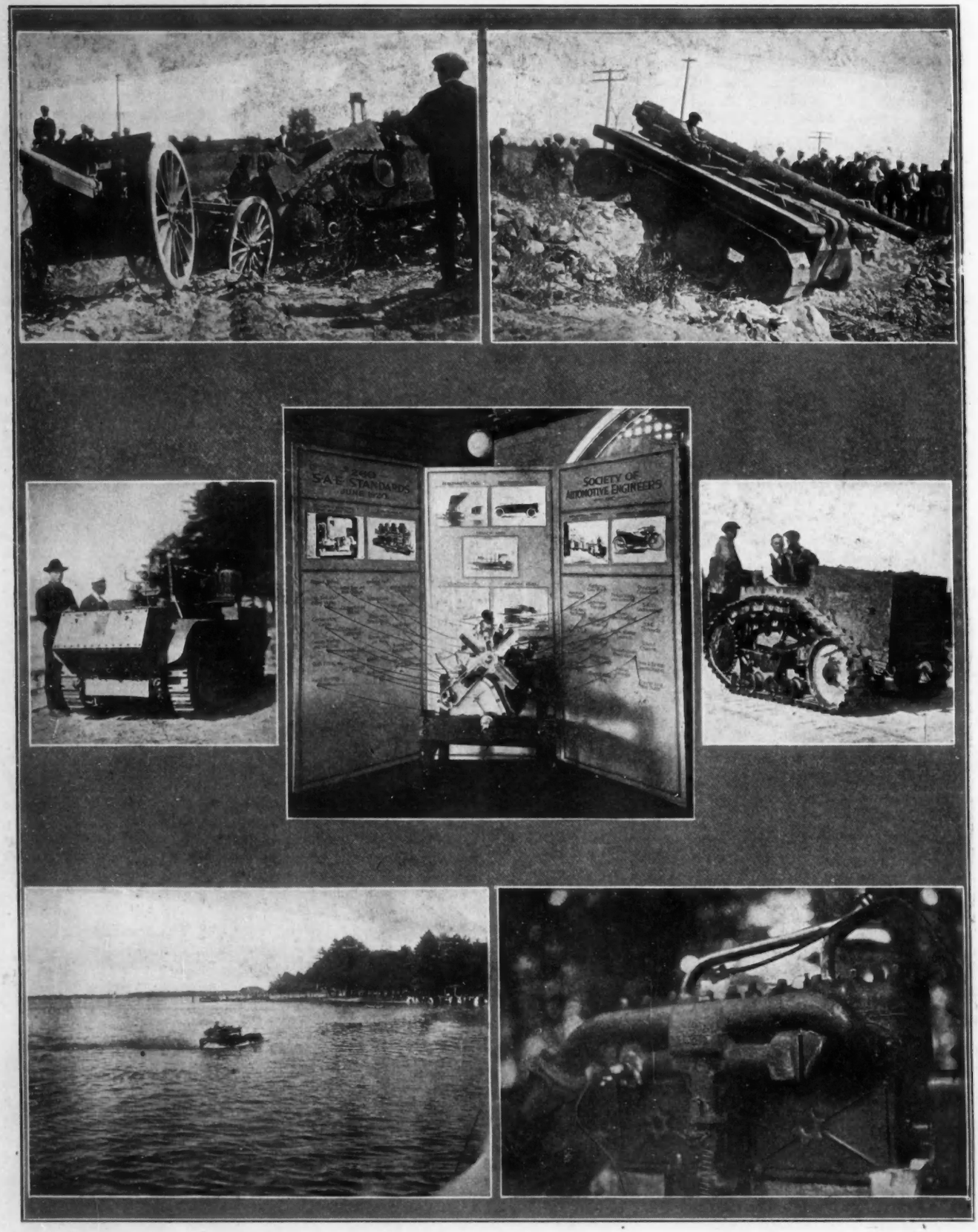
about alcohol is that it can be produced in unlimited quantities whenever required. So long as the sun shines and water can be obtained, that is, while we can obtain heat and moisture, alcohol can be produced and the material from which we produce it can be obtained in a single season. Some years ago I gave enough attention to alcohol as a fuel to satisfy me that there is nothing in the claims made regarding low-cost alcohol, say at 4 or 5 cents per gal., when made from waste materials. Whenever alcohol does come into general use, if ever, it will not be made of waste materials. It will be made in an intelligent way from fruits or grains adapted to the purpose, with the least possible expenditure of labor. Human labor will be the important factor. It has been said that there is an unlimited quantity of seaweed that can be made into alcohol. It could, but it never will be, for the same reason that no mining company will spend dollars to get a few cents' worth of gold out of ore. Alcohol may prevent us from worrying about the fuel supply for our descendants. They will always have heat, light and power, at a price. It will not be relatively a high price, but it will never be 4 or 5 cents per gal.

Regarding oils obtainable from shales, it was said some years ago that in a certain district there was enough oil recoverable from shales not yet worked to more than equal all the water now in Lake Superior. There is no question that there is considerable oil in some of our shales, but the production of oil by distillation is not a cheap process. At present we must confine ourselves to gasoline and kerosene as they are. I believe we will not be worried very much by the advancing price, although we may have several further slight advances. We are suffering from a slight shortage of oil more than from high prices. I agree with Mr. Horning that, speaking relatively, the present prices of gasoline and kerosene are not so very high.



SPORTS AT THE SUMMER MEETING

Some Idea of the Interest Which the Athletic Contests Aroused Can Be Gathered from the Two Views at the Top of the Page, While Directly Underneath Are Two Who Were Largely Responsible for Their Success, George T. Briggs and Howard Spohn. In the Lower Left Corner Is a Picture of the Tennis Doubles and at the Right the Band of the Continental Motors Co., Which Played for the Sports and During the Dinner Hour Can Be Seen in Action



SOME OF THE EXHIBITS

The 2½-Ton Ordnance Tractor Hauling a 75-mm. Gun Carriage and Limber

The Wheeled Caterpillar Tractor for the 150-mm. Gun in Some Rough Ground

The Mark VII Self-Propelled Caterpillar Mount for 75-mm. Gun

Exhibit of S. A. E. Standards

The 2½-Ton Tractor Showing Special Traction-Increasing Device

The Mark VII Caterpillar Mount Partially Submerged

One of the Manifolds Used in the Engine Operation Test

PROMINENT ATTENDANTS AT THE MEETING

C. A. Norman
N. B. Pope
R. W. Lohman

The Meetings Committee
Some of the Council
W. G. Wall

Col. T. H. Bane
F. M. Germane
O. B. Zimmerman

Notes on Power Farming

By R. W. Lohman [1] (*Member*)

Semi-Annual Meeting Paper *Illustrated with* Photographs and Charts

THE following notes relate to some of the methods and apparatus which can be used to advantage in large scale farming operations. Herein are discussed the laying out of a production program, the transportation of men and supplies, special implements for raw land preparation, tractor dynamometers, large tractors, special plowing and tilling implements, four-wheel-drive tractors and road haulage.

Operation Chart

Let it be assumed that a large area is available, say 40,000 acres; that flax and wheat are to be the crops; that 24,000 acres are to be put under cultivation the first year, 12,000 of which are to be broken, packed, and seeded to flax and that the remaining 12,000 are to be broken, packed, disked, harrowed and finally seeded to winter wheat, this being a usual method in the dry farming regions of the Northwest. Let it be further assumed that wheat only will be grown in succeeding years, that all crops must be hauled 40 miles by tractor train to effect delivery to the railroad, and that operations must be conducted within the narrow time limits set by the Northwest climate as follows:

Operation	Begin	End
Plowing, packing, disking and harrowing	March 1	April 1
Harrowing (3 times)	May 1	Aug. 1
Harvesting	Aug. 15	Sept. 1
Seeding	Sept. 1	Sept. 15
Threshing	Sept. 1	Oct. 15
Hauling	Sept. 1	Nov. 1

This schedule contemplates operation after the so-called "Middle West" method, of binding and shocking or heading and stacking and threshing.

In Fig. 1 is an operation chart or production program for the given crops and time limits such that, if the indicated operations can be followed, men and equipment can be kept in active service for the maximum percentage of time per year and the investment thus in machinery reduced to a minimum. The lower half of this chart represents the field "A" to be seeded to flax. It will be noticed that the tractors selected have been confined to two sizes, 45 and 120 hp., although, of course, sub-multiples of these capacities with a corresponding increase in the number of each would produce the same result. Calculation will show that six 120-hp. tractors can plow, disk and pack, allowing for delays, as will be shown later, 9700 acres in thirty elapsed days of 20 operating hr. each, beginning April 1 and ending May 1. Similarly, seven 45-hp. outfits can in fifteen days of 20 hr. each cover 2300 acres, which will thus allow the larger tractors later to complete the 12,000 acres within the time specified. The 45-hp. machines can then be coupled to the drills and packers and in thirty days of 20 hr. each they can seed the entire 12,000 acres as indicated in the upper portion of field A from April 15 to May 15.

The larger tractors having completed their work on the flax tract should then be transferred to the raw land which it is desired to prepare for winter wheat; represented by the upper half of the chart labeled field "B." It is always desirable to perform any given farming operation in the shortest possible time for best agricultural results, this being only one of the handicaps under which the farmer labors in comparison with the average manufacturing plant which, in general, has an approximately constant load and employment factor throughout the year. In the case at hand, that of plowing, disking and packing, it is desirable to do this as rapidly and as early in the season as possible in order that rainfall may be absorbed by the plowed ground and not allowed to run off and become lost as far as crop production is concerned by the hard impervious unbroken ground.

Thus we have in the lower half of the field B a block of thirty 20-hr. days from May 1 to June 1 for the 120-hp. tractors, or an equivalent number of 60-hp. outfits which, when supplemented with the seven 45-hp. tractors from May 15 to June 1, will suitably plow, disk, pack and harrow the 12,000 acres for wheat, these smaller machines having been transferred from field A after having completed the drilling and packing of flax there. The 45-hp. tractors after completing that operation may be coupled to disk or spike-tooth harrows as weather conditions require and kept at harrowing, particularly after each rain, to break up any crust thus formed and further conserve moisture. Owing to this "rush job" feature it is now found that the 120-hp. tractors will be idle in this tract from June 1 to Aug. 15, and they can therefore be transferred to the remaining area of the 40,000 acres assumed to be available, for clearing sage brush, or put at road-making, grading or hauling. Reverting to field A there is another rush job on hand. Flax being a 90 or 100-day crop will be ready for binding about Aug. 15, and when once ripe it must be harvested rapidly to avoid a large percentage of loss from shelling out, etc.

If the old-time binding and multi-rehandling method must complete the job between Aug. 15 and Sept. 1, it will be found that six 45-hp. tractors, one being kept in reserve for hauling supplies, with two 12-ft. push binders each and the six 120-hp. outfits with three push binders each, actually operating 12 hr. per day, will cut about 860 acres per day or 12,000 in fifteen days, as shown in the lower and upper blocks of field A at that time. As soon as the smaller tractors have completed their share of the binding they must be hurried to field B where they are allowed fifteen days to seed 12,000 acres of the wheat land which was thoroughly prepared earlier in the season. This, six of them can do at 125 acres per 12-hr. day, one being kept in reserve for hauling seed, grain, etc. In the meantime two 120-hp. tractors will each be required to operate two threshing machines, 12 actual hr. per day

[1] Agricultural engineer, New York City.

for forty-five days, as shown by the lower block of field A from Sept. 1 to Oct. 15. During this period the four remaining tractors will be engaged in hauling trains of ten wagons, each weighing 2 tons and carrying a live load of 4 tons, a total load of 60 tons or 40 tons of grain. The 45-hp. tractors also after completing the drilling of wheat on field B must be put on the road with three wagons each, but it will be found that with even this excessive investment in wagons and tractors a good crop, 25 bu. per acre, from 12,000 acres cannot be delivered 40 miles away between Sept. 1 and Nov. 1. With good luck it may possibly be accomplished by Nov. 15, as the dotted lines indicate, but at that time of year rains and impassable road conditions are usually expected and delivery will probably become impossible. The problem of long-distance haulage by tractor and wagon train is a very serious one and some remarks concerning it will be made later.

Without taking time to go into details of the second and succeeding years' operations it may be pointed out in general, and noted on the chart, that after the land is once broken and one-half sowed and the other half seeded to wheat each year alternately, the mechanical operations become less congested; that is the overload factor is reduced, the operations may be spread out over a greater length of time, or, conversely, if night-and-day operation is still preferred, less equipment will be required to get through on schedule time than is required during the first year, on account of the elimination of the short-term flax operations, etc. In surveys made by the Department of Agriculture in the past two or three years it is reported that the actual number of days' work put in by tractors on the average farm in Illinois is only forty-five per year. In the Dakotas this average is fifty. In New York it is forty-seven. From a study of this operation chart it will be seen that, including night-and-day runs, 240 days' work per year is required from the large units and almost the same from the smaller units, which would indicate a rather efficient time use of such equipment if it can be so operated.

Having thus taken a hasty glance at the program which it is desired to follow, some of the factors involved in such a program may be mentioned.

Hours of Operation

I maintain that with a suitable organization and proper selection of motive power and implements, tractors can be kept in motion 20 hr. per day. The time-table for the crews under such schedule may be about as follows:

	Day Shift	Night Shift
	A. M.	P. M.
Arrive at Tractors	*6:00*	**6:00**
Start Work	*6:30*	**6:30**
	NOON	MIDNIGHT
Stop	**12:00**	*12:00*
	P. M.	A. M.
Resume Work	**12:30**	*12:30*
Finish Work	**5:30**	*5:30*
Total Running Time, hr.	10½	10½

This is a total of 21 hr., which will allow 1 hr. for minor adjustments, etc. However, the maintenance of such a schedule requires careful attention to many details, among which are headquarters or camp arrangement, transportation of crews and supplies and the employment of special loading and supply crews. Sleeping quarters for the night crew should be located some distance from the center of camp or at least away from the noise of the machine shop, passing trucks, etc. The providing of plenty of shower baths is almost imperative.

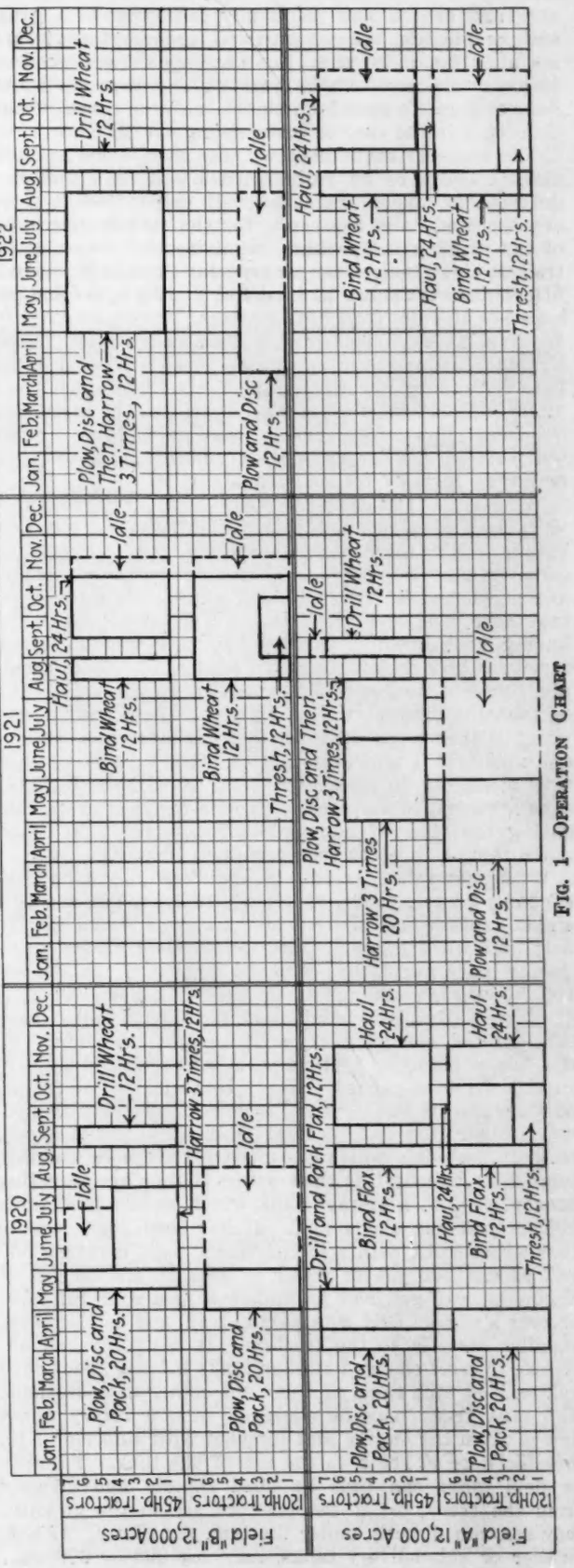

1920
1921
1922
Jan. Feb. March April May June July Aug. Sept. Oct. Nov. Dec.
Field "A" 12,000 Acres
Field "B" 12,000 Acres
120Hp. Tractors
45Hp. Tractors
Plow, Disc and Pack, 20 Hrs.
Drill Wheat 12 Hrs.
Harrow 3 Times, 12 Hrs.
Idle
Plow, Disc and Then Harrow 3 Times, 12 Hrs.
Plow and Disc 12 Hrs.
Haul, 24 Hrs.
Bind Wheat 12 Hrs.
Thresh, 12 Hrs.
Drill and Pack Flax, 12 Hrs.
Bind Flax 12 Hrs.
Plow, Disc and Then Harrow 3 Times, 12 Hrs.
Harrow 3 Times 20 Hrs.
Plow and Disc 12 Hrs.

Fig. 1—Operation Chart

Dreams of 12 hr. in a dusty field behind a boiling radiator and engine and plentifully bedaubed with grease and perspiration, are not apt to incite promptness in arising at 5:15 a. m. or p. m., but a cooling shower, good and ample meals, comfortable quarters and payment by the hour or acre for such long shifts, make an extraordinary difference in the ease of maintaining the schedule.

The transportation of crews may seem to be an insignificant factor on an ordinary farm but the situation is different in larger operations. If only fifteen tractors are operated from one camp, for the simpler operations of say plowing and packing, requiring only two men per tractor, this requires the transportation of thirty men to fifteen different points at least 1 or 2 miles apart and perhaps 5 or 10 miles from headquarters. The opportunity for losing a large number of man-hours which mean tractor hours in this operation is excellent, and will account perhaps for sundry Fords being generally found in such service. Each Ford is often loaded with six or more men, bundles of plowshares, various repair parts, cans of drinking water and other necessities, and has to travel along or across furrows for many miles.

To operate the tractors with only 1-hr. shutdowns morning and night and ½-hr. shutdowns at noon and midnight it is necessary to take the fresh crews from camp in time to arrive as shown in the table morning and night, and to transport on the return trip the crews that have completed their runs. The off-coming crews, having shut down ½ hr. earlier, have had an opportunity to go over all suspected bearings or loose crankpins and clutches, or other parts that have given trouble on the run, and report them fully to the on-coming crew, which is then responsible for their adjustment. At noon and midnight it will generally be found advantageous to take meals out in an express body Ford in well-packed cans arranged in suitable boxes, one for each crew, thus saving the time of a complete round-trip with consequent loss of time for each crew and tractor.

With only a few tractors in operation plowshares, oil, gasoline, grease, water, etc., can usually be put aboard a single express body Ford when the crew starts for the field, but when consumption reaches 2000 gal. of gasoline or more per 24 hr., a barrel or two of oil, and say 150 plowshares, other methods must be employed. It is of course desirable to handle such supplies in bulk. Tank cars spotted alongside a gas house may be coupled to the house through a stand-pipe which should contain substantial, well-packed swing joints and not the usual combination of one or more standard elbows which always either rust fast or leak. In the gas house should be located a pump which can discharge through a swing-joint filler directly into the tractors if they are operating nearby, or into a storage tank which should preferably hold a tank car and a half. It has been found that a four-wheel truck with a compartment tank, carrying 550 gal. of gas, 100 gal. of water or gear oil and 55 gal. of engine oil, can get over an unplowed field with full load, or over a plowed field with partial load, and deliver these supplies directly to the tractors. It will be found advisable to erect elevated storage tanks holding about 8500 gal. each at each camp at about the center of operations. The tank truck may be equipped with a rotary pump driven from the engine and supplied with sufficient 1-in. metallic hose to reach to the top of the tank. Tractors or field tanks can thus be filled rapidly and directly from the truck, or, if the tractors are in the vicinity, they can run directly under the tank for filling. If not, smaller or sub-delivery tanks, carrying 200 or 300 gal., hauled by a small tractor may load from these field tanks and take supplies to the smaller outfits. The night-and-day schedule set forth above could not possibly be maintained if all of the routine work necessary to start up were performed by the operating crew itself. It will be found necessary to provide three to five extra men per outfit, for ¼ or ¾ hr., depending upon the size of the tractor and the string of implements it is hauling, to fill all oil, water and gas tanks; to screw down and refill all grease-cups, to fill all oil-cups, to change plowshares, make minor adjustments and tighten up bolts, cables, etc., on the implements within the time allowed for such shutdowns.

In practice the oil and gas trucks are ordered alongside the first tractor 10 min. before stopping time; when the tractors have shut down, the driver of the truck with one helper puts aboard all oil, gas and water needed and immediately proceeds to the remaining tractors for the same purpose. The loading crew, morning and night, screws all grease-cups on the implements way down and refills them. At noon and midnight the cups are screwed down half way. This crew also treats in a similar manner all grease-cups on the tractor which have been specifically designated by the engine-man. The engine-man generally prefers to handle a few particular cups himself, and these are not touched by the loading crew. This is true also of the oil-cups. They then change shares on the plows or do whatever is necessary on the attached implement and proceed with their foreman to the next tractor. In the meantime the engine crew are eating their lunch uninterruptedly and are allowed 20 min. therefor, giving them 10 min. to inspect the oiling and greasing done by the loading crews and to lubricate such special parts of the engine as they prefer to keep under their own supervision. Morning and night the laying-off crews shut down ½ hr. before the end of the shift, look their outfits over, inspect the crankcases, note any adjustments which the day's experience has indicated as necessary, make out their daily reports, talk over engine operating matters with the incoming crew and leave for camp. In the meantime the supply and loading crews have performed their functions and the operating crews coming on duty have only to make adjustments, attend to the special oiling and check up the oiling done by the loading crew. The necessity for such loading crews and routine will become apparent from observation of the large number and size of the equipments necessary to perform the work outlined.

Electric Lighting

Of course night operation is not feasible without satisfactory lighting, and this very few tractors are provided with. Only a few manufacturers sell tractors with complete lighting systems as a part of their regular equipment; others will supply it under protest. In neither case is the complete installation given the attention which it warrants. Even the regularly equipped tractors are wired indifferently, generally with long festoons of loose wire which soon become entangled with the operator; the battery is improperly housed and supported, the switch is a flimsy affair, and the lamps generally disintegrate in a few weeks if they do not fall off the tractor altogether. There is on the market an extremely rugged type of charging generator, inherently self-regulating throughout a wide range of speed and automatically cutting in or out of circuit at the lower speed limit by a self-contained centrifugal switch. It has proved very satisfactory in service. There is also a type of generator regulator which, while it has given excellent satisfaction on automobiles and trucks, was in-

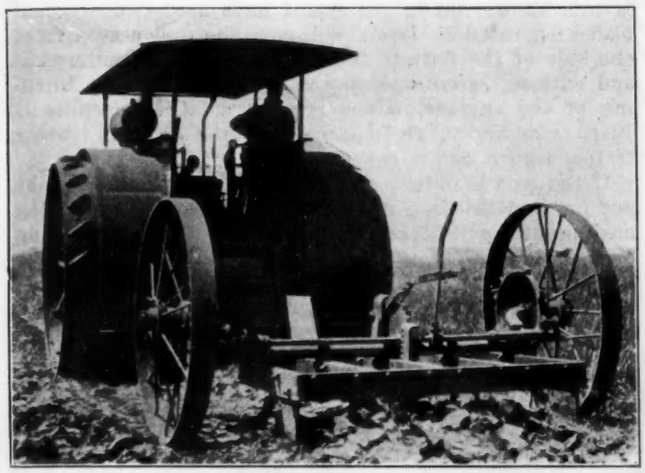


FIG. 2—SUB-SOIL PLOW IN ACTION

stalled on some tractors on an overhanging non-rigid shelf or bracket directly under the engine support. In operation the vibrating armature of this regulator is in continuous motion and opens and closes a shunt across the generator field. Conditions were such that, with the engine running at 550 r.p.m., the bracket performed a similar number of oscillations and kept the contact points so busy in between their regular journeys that only occasionally could a momentary dab of current get through. This resulted in no battery charging current and the shutting down all outfits on the night runs, illustrating what has been said in regard to insufficient attention on the part of the manufacturer to the complete lighting system. For another illustration it is only necessary to look at the connectors and fittings usually supplied. They are generally the assortment found on the lower-priced automobiles. The caps are of soft flaky composition and generally crack; the threads are poorly cut and always strip off; the springs are so weak that the heavy jarring due to the engine will in many instances open the circuit every revolution; the screws and the caps and the holes in the latter are so small that a stranded and heavily insulated wire, such as should be used on a tractor, cannot be accommodated. These may seem to be insignificant items and they are from the manufacturer's standpoint, but when an $8,000 or $10,000 outfit is shut down, wages at $20 a night are going right on; and the crop may not be visible at the end of the season simply because a 2-cent screw would not stay in a loosely tapped hole, the headlight was out of business and the crew could not see where to go. The operator takes a different view of the subject.

I believe that there is no line of fittings, switches, plugs, etc., especially designed for tractor use, and feel that there is certainly sufficient demand for such devices to warrant the makers of standard electrical fittings in bringing out a substantial line. It has been found necessary, to secure dependable night service, to install standard house wiring fittings such as standard attachment plugs and receptacles of composition base, not porcelain, portable hand-lamps which are built for 110 volts and into which adapters must be fitted on the socket end for 6-volt lamps and standard switches. Switches should be large and substantial and indicate by the position of the handle whether they are on or off. An operator can fumble for such switches in the dark, open or close them even with heavy gloves on and not lose time trying to light a match in the wind to see if they are on or off, if there is trouble with the lamps or wiring.

FIG. 3—POWER DRAIN BUILDER AT WORK

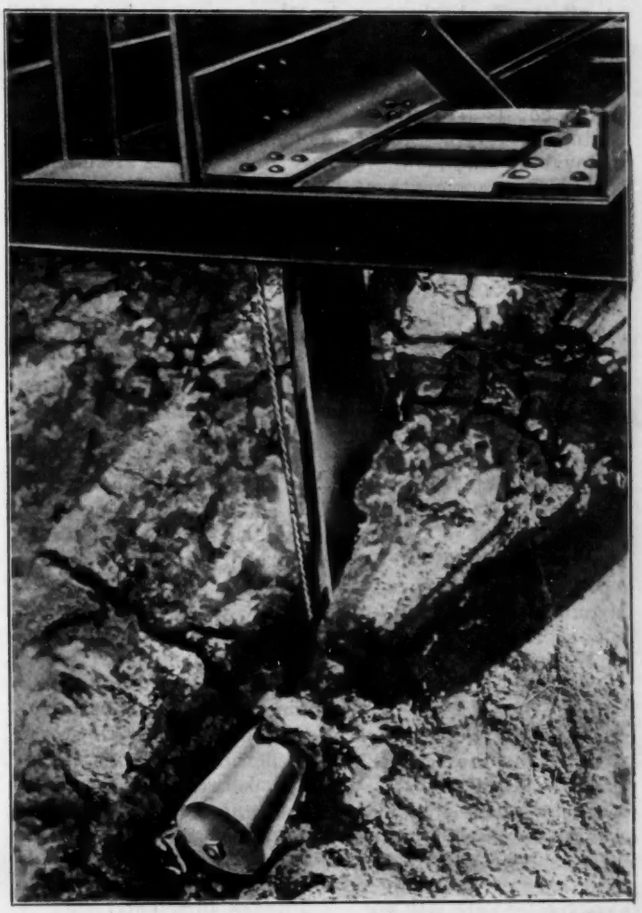


FIG. 4—THE KNIFE AND PLUG OF THE DRAIN BUILDER

IMPLEMENTS USED IN RAW LAND PREPARATION

If the land is very bumpy and 1 or 2 ft. must be removed from high spots to level it for irrigation, it can

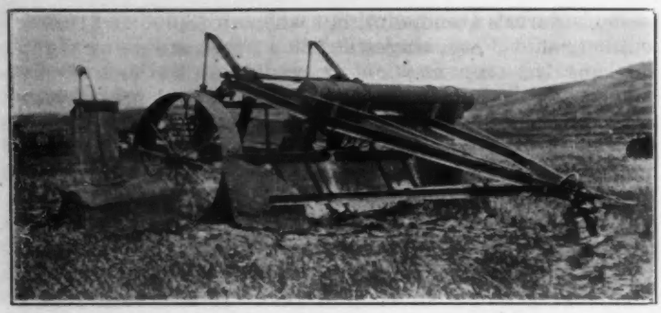


FIG. 5—THE MACHINE SCRAPER

be effectually broken up by the use of a "sub-soiler" such as illustrated in Fig. 2. This is a real tractor implement as can be seen by its extremely rugged construction and ample wearing surfaces. The one illustrated consists of five ¾ by 8-in. vertical steel blades, having removable knives along their front edges and removable points at their lower ends. These are clamped between the members of the heavy plate frame shown, the frame being carried by a crank axle which is provided with a power-lift gear. These blades when set 12 to 18 in. apart and 18 in. deep, will, in dry soil, absolutely crack and crumble the entire cross-section encountered by the implement, as shown in Fig. 2.

The drain builder shown in Fig. 3 cuts a narrow slot in the ground 4 or 5 ft. deep and pulls a conical plug through the ground at the bottom of the slot, thus opening up a passage 4 or 6 in. in diameter. It is seen in the illustration with the rear end hanging over a drainage ditch in which position it may enter the bank. In Fig. 4 is a detail of this knife and plug. To operate one of these implements three 75-hp. tractors are required and it is obvious that they must be built substantially.

After the surface has been broken up to the desired depth and drainage provided for, a scraper, Fig 5, may be employed to advantage to level it roughly. At the left an ordinary two-horse scraper is shown for comparison. To do the work of this implement with horse scraper would require thirty-six horses and nine men, while a 75-hp. tractor and two men will move about 4 1/3 cu. yd. per trip. It is operated by compressed air stored in a tank on the scraper, and generally fed from a compressor on the tractor. The bucket can be gradually raised or lowered by a three-way valve and a thin slice of earth taken off and gathered up or it may be deposited in the low spots in equally thin slices or dropped in a hole all at once. An expert operator at the valve of one of these implements will leave a surface sufficiently smooth for average use but if it is to be put under irrigation a leveller should be used. The ordinary float or leveller is well known but in the type I have used two diagonal blades operated by levers will pass the dirt across from one side of the float to the other after it has entered it and with an active operator will permit complete finishing of the surface in one trip over. This machine is 12 ft. wide and 32 ft. long and can stall a 60-hp. tractor if too deep a cut is taken.

If the land is to be irrigated, borders or levees must be put up, and this can be done with tractors through the medium of the "Checker." Such an implement, by taking off 1 in. of dirt for 10 to 12 ft. on each side of the center line, will put up a levee 18 in. high and 5 ft. wide at the rate of from 15 to 20 miles per day. In very heavy soil to put up a large levee will require two 75-hp. tractors in tandem. A steel blade about ⅝ in. by 8 in. by 6 ft. is fixed longitudinally along the center line of these checkers and prevents them from slewing from side to side, with the result that a levee can be put up just as straight as the engine-man can steer.

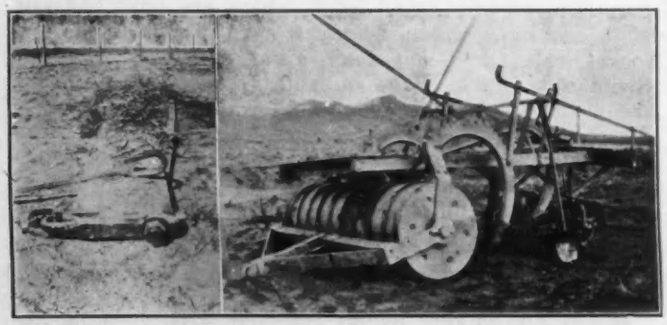


FIG. 6—THE RAIL DRAG AND THE PLOW USED FOR BREAKING LAND

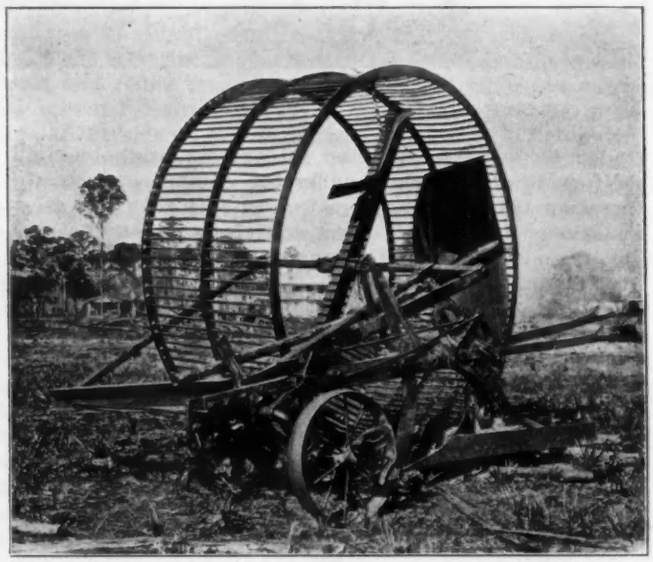


FIG. 7—THE ROOT THRASHER

If the raw land has light sage brush on it, it can probably be "dragged down" by a combination of railroad rails thoroughly bolted and clamped together at the ends, as shown at the left of Fig. 6, and trussed at the center with an end-to-end truss-rod. If the growth is heavier it will have to be rolled and plowed, which can be done with some such plow as that shown at the right of the engraving. The rollers in front consist of steel tires and side-plates filled with concrete; these break down and mash the larger stalks. At the rear will be seen plow beams with extraordinary clearance, carrying at the lower ends, middle breakers; these cut off and throw out most of the roots and crack the soil to the depth set.

Formerly it was a tedious job to go over the prairie with a species of heavily built hay rake, rake up the brush in windrows and burn it. Now this can be done largely with a "root thrasher" illustrated in Fig. 7. This consists of a large moldboard plow which turns the furrow into the squirrel-cage at its right and rolls upon the ground. The dirt sifts through, while the roots adhere to the cross-bars until they approach the top of the circle, where they fall upon the wide deflector which is not shown in its normal position, and slide into a low wagon

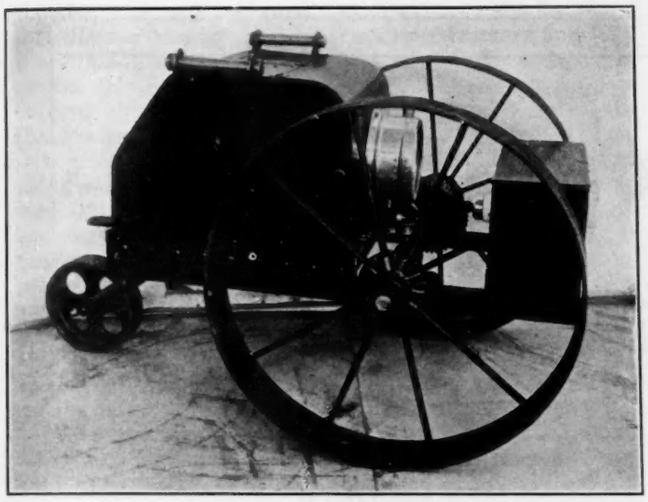


FIG. 8—A SELF-CONTAINED DYNAMOMETER CART

hauled alongside the squirrel-cage. With such preliminaries we may leave the preparation of the raw land and turn to straight agricultural operations.

POWER REQUIRED FOR VARIOUS OPERATIONS

Five or ten years ago there were no instruments by which the actual drawbar pull of a tractor could be satisfactorily obtained in the field, under actual operating conditions. The nearest approach was the Pioneer Chatillon instrument, which had no dashpot, or time or distance recording devices, but deserves credit as being the first effort in that direction. Now we have a number of medium-sized equipments.

A completely self-contained instrument adapted to long runs is shown in Fig. 8. The case contains all the recording mechanism. The right-hand wheel is geared to this mechanism as shown, and the front end of the carriage is coupled to the tractor at any convenient point of the drawbar, while the load is coupled to the tractor through the cylinder shown in Fig. 9. A flexible tube connects this cylinder through the piping *A* shown at the left of Fig. 10 to the horizontal cylinder *B* of the indicator whose piston is connected through levers to the rear of the two pens *C* also shown at the left. The horizontal glass circular window *D* at the top of the machine covers an ingenious mechanism known as the integrator. Its function is to integrate, in the same manner in which a planimeter would, the area between the base-line and the drawbar-pull line. Every square inch of record or area thus obtained is totaled up on a counter *E* shown at the right of the integrator and at the same time the second pen to the right at *F* puts a nick into the line which it is drawing. The third pen to the right is driven by a clock and also nicks its line every 30 sec. The pen at the extreme right is electrically operated by a push-button and can be used to record any particular event, such as entrance into hard ground, slippage of the tractor, etc.

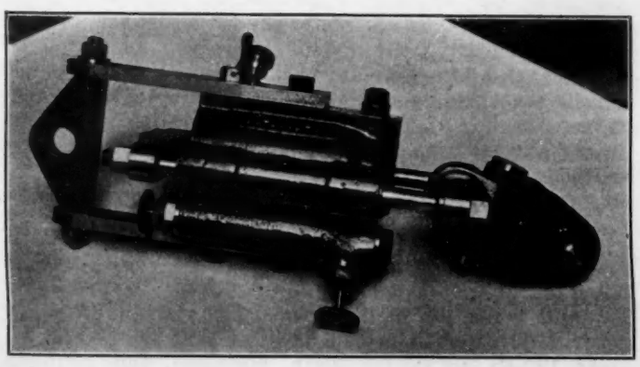


FIG. 9—THE CYLINDER THROUGH WHICH THE PULL IS TRANSMITTED

In Fig. 11 is a typical record at about one-tenth load, the first line from the top being the datum; the second is the drawbar-pull record; the third is the interesting "Integrator" record. It can be seen from this record or from the counter upon which the square inches have been added up, that the total number of foot-pounds delivered by the tractor to the implement are available. From the fourth record the time during which this effort was expended is available and dividing the integrator record by the latter and multiplying by a constant, the average horsepower input is determined, or, by dividing the

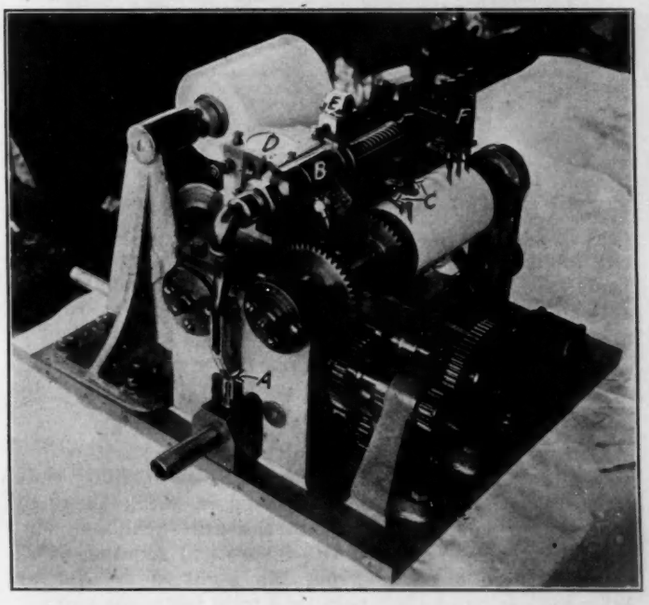


FIG. 10—THE RECORDING MECHANISM OF THE DYNAMOMETER

total foot-pounds from the recorder, by the feet travelled, the mean drawbar pull is obtained. There are other satisfactory dynamometers on the market and there is no longer any reason for rule-of-thumb methods in implement and tractor testing. From tests with such instruments it is well known that the draft required by the average moldboard plow in an average tillable soil varies between 7 and 20 lb. per sq. in. of furrow slice, or 400 to 800 lb. for a 14-in. plow. On the basis of 600 lb. per plow a 120-hp. tractor having a drawbar pull of 12,000 lb. at 2.25 m.p.h. should pull twenty bottoms or a strip 23.3 ft. wide. It should be stated, however, that tractors of this size are essentially "War Implements," that the makers have found the demand to be insignificant in comparison to the demand for 45 and 75-hp. machines and that their manufacture has been discontinued.

A 23-ft. swath 4 in. deep is equivalent to about 5.2 engine hp. per ft. of cut. A single disk drill requires in medium soil ¾ to 1 hp. per ft. of cut, double packers ¾ to 1¼ hp., spike-tooth harrows 1¼ to 1¾ hp., and double disk drills 1¼ to 2 hp. All of these drafts can be in-

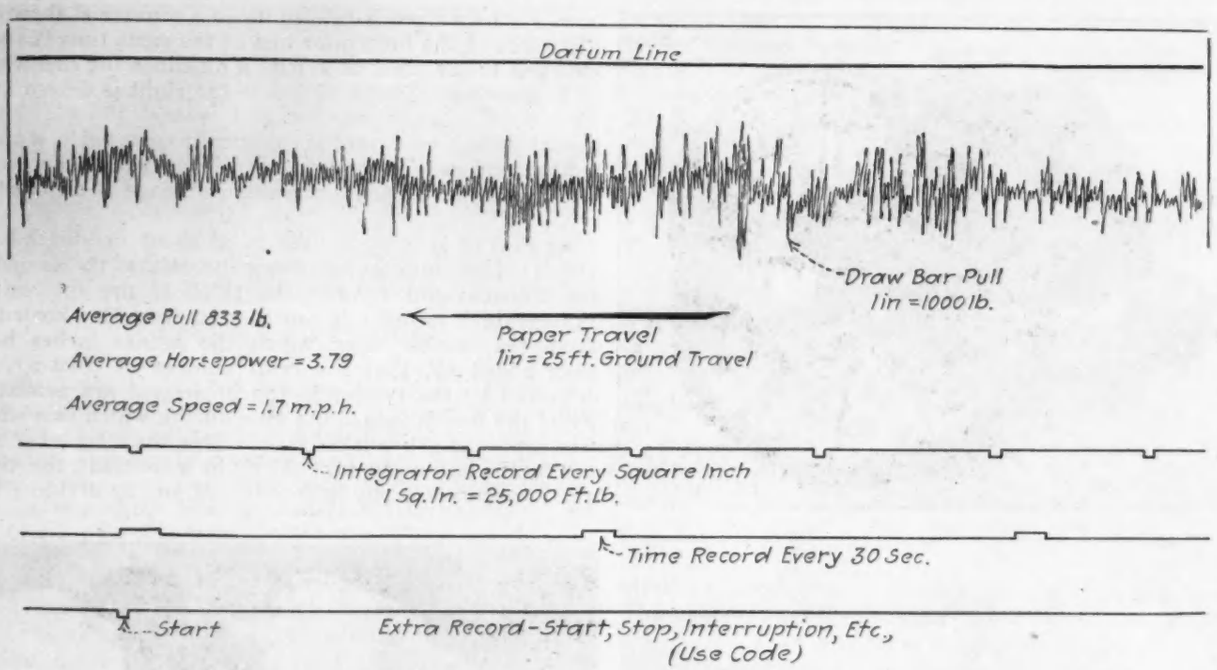

Datum Line
Draw Bar Pull
1 in = 1000 lb.
Average Pull 833 lb.
Average Horsepower = 3.79
Average Speed = 1.7 m.p.h.
Paper Travel
1 in = 25 ft. Ground Travel
Integrator Record Every Square Inch
1 Sq. In. = 25,000 Ft. Lb.
Time Record Every 30 Sec.
Start
Extra Record - Start, Stop, Interruption, Etc., (Use Code)

FIG. 11—TYPICAL DYNAMOMETER RECORD

creased from 50 to 100 per cent by wet, heavy soils and they will vary with the design of the implement, depth of cut, angle of the disks, etc. With this information as a basis it will be seen that a 120-hp. tractor should theoretically plow, double disk, seed, pack and harrow in one operation about a 16-ft. swath. This is equivalent to

$$\frac{2.25 \times 5280 \times 10 \times 16}{43560} \text{ or } 43.5 \text{ acres}$$

every 10 hr. or, theoretically, 87 acres per 20 hr.

Owing to the difficulty of getting supplies to the tractors and men at night, the occasional loss of filling cans, tools, etc., the loss of time involved in going ahead on foot to see where to turn into the next headland, etc., only about 85 per cent of the theoretical acreage, or 37 acres, can be expected from the night shift over an extended period of operation, or a total per night and day shift of 80 acres. Furthermore, inevitable delays will be caused by minor engine and implement adjustments, waiting for supplies or parts, miring down, disconnecting the load to pull across slippery spots, etc., and at best about 12 per cent more should be allowed for such causes with careful management, equivalent to 70 acres per night and day shift.

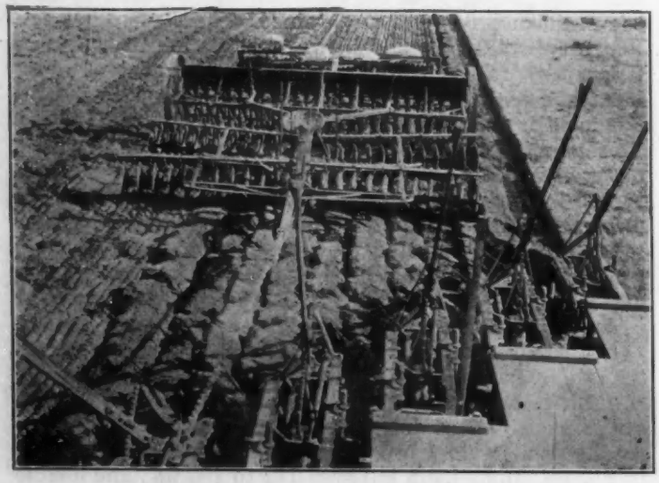


FIG. 12—VIEW FROM THE TOP OF A TRACTOR SHOWING THE VARIOUS IMPLEMENTS AND THE UNBROKEN PRAIRIE

Another source of delay which must be considered is poor weather. From the Weather Bureau records of rainfall in the region in which it is desired to operate it will be found that the average rainfall during the plowing season and the number of days which it may be expected to rain in these months is:

Month	Rainfall, in.	Rainy Days
April	1.50	5
May	2.25	9
June	2.60	6

Assuming that all plowing and disking must be done in these months, the days upon which it does not rain are therefore 78 per cent of the elapsed time. This would reduce the available time, or the effective plowing capacity say 25 per cent, or to 52 acres per day of elapsed time. Thus the total reduction factor from the 87 acres per 20-hr. day which it is theoretically possible to plow, disk, seed, pack and harrow to the 52 actual acres which can be so treated throughout any given month, is 60 per cent, and this, excluding serious breakages or repairs, can be taken as a reasonable delay factor. Thus it will be seen that if 12,000 acres are to be seeded to flax in thirty elapsed days, the number of 120-hp. tractors required would be

$$\frac{12000}{52 \times 30} \text{ or } 7.7 \text{ tractors}$$

This neglects the capacity of the seven 45-hp. tractors noted on the operation chart and required for other service, and which by similar calculations should actually cover 2380 acres in fifteen days, so that six instead of eight 120-hp. or twelve 60-hp. machines, can complete the work if assisted by the smaller outfits as shown on

the chart. It will be noted that the chart calls for plowing, disking and packing by the larger tractors only and the subsequent seeding and packing by the 45-hp. machines only. However, the entire operation can be performed either way in the same total elapsed time with the equipment provided.

Fig. 12 is a view from the roof of a 120-hp. tractor cutting about 12 instead of a possible 16 ft., the reduction being necessary on account of the heavy grades encountered. The various implements which the tractor is pulling are shown, the first being five of the ten 14-in. plows, followed in turn by 12 ft. of double-disk harrows, a seeding machine and a double packer. Frequently a spike-tooth harrow is added to the combination, although this is not shown in the illustration. On the right can be seen the unbroken prairie with small sage brush and on the left the flax in the ground in a perfect seed-bed.

In regard to the necessity of loading crews it may be said that this once-over outfit has no less than seventy-four grease-cups on it, not to mention a few oil-cups and a force-feed lubricator. Three or four smaller outfits capable of doing the same work would have even more.

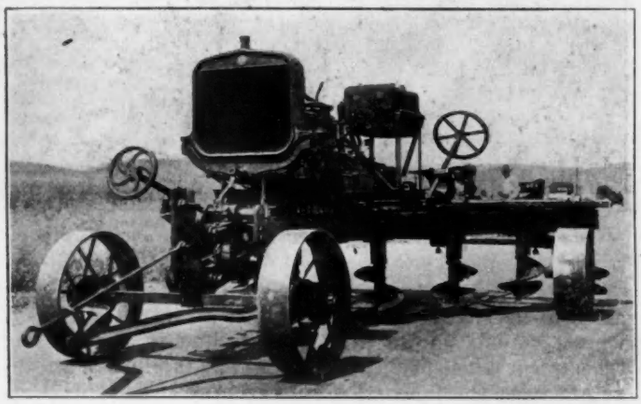


FIG. 13—A PLOW WITH ROTARY SPIRAL CUTTERS

Supposing it required only 1 min. to unscrew, load and screw down an oil-cup, this $10,000 outfit would be useless for 1¼ hr. if one man only were put at the job. How many men who have used the average exasperating grease-cup would guarantee to do the work in 2 min. per cup? They know that with greasy gloves or fingers it is practically impossible to turn such cups in the cramped locations in which they are generally placed. In a large percentage of the cups supplied by tractor manufacturers the thread at the base fits into the hole so loosely that the entire cup comes out each time an effort is made to unscrew it, especially when the cap threads are poorly cut, so that a pipe wrench has to be applied to feed any grease. This 1¼ hr. does not include the time necessary to put 75 gal. of gasoline, 15 gal. of water, 2 or 3 gal. of oil and 10 gal. of track oil aboard, and take off old plow shares and put on new ones.

It is always most desirable not to run over plowed ground with heavy machinery, even tracklayers, much less those of the round-wheel type, if it can possibly be avoided. To do so is, in effect, to roll down and heavily pack the very soil which it has cost considerable time and money to turn up and loosen. It seems strange that more devices for completing all possible operations in one trip over the field have not been developed. A few such implements are on the market, however, and deserve

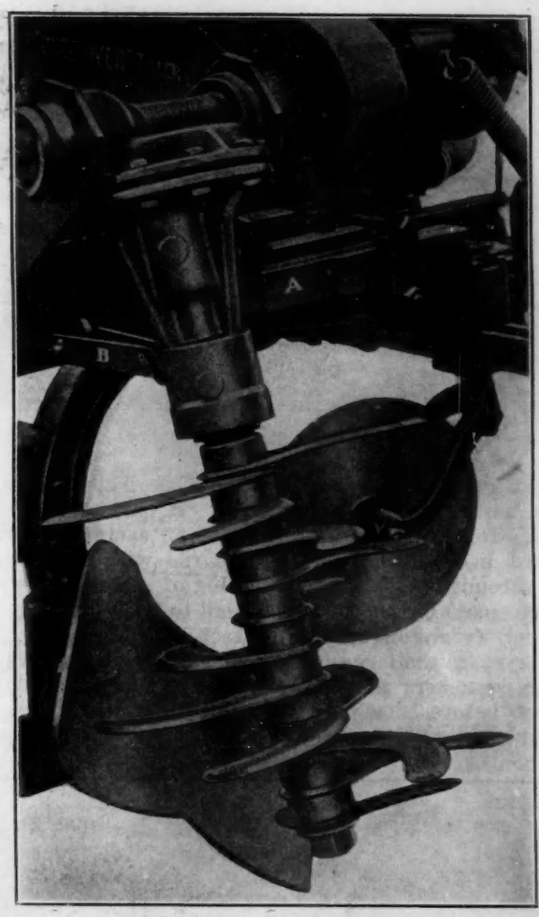


FIG. 14—THE MOLDBOARD OF A PLOW CONSISTING OF A VERTICAL SHAFT AND ROTATING KNIVES

mention here. Fig. 13 is a front view of a spiral plow which consists of six spirals 14 in. in diameter with inserted manganese steel cutter-bars set as shown on vertical axes and driven at from 100 to 400 r.p.m. by a 40-hp. engine. This implement does not turn a furrow upside down and thus would not permit the turning under of a cover crop for instance, but it does mix the lower soil with the top layer and pulverize the whole thoroughly, to a depth of 14 in. if desired.

In Fig. 14 is shown the principle of the "Once-Over Tiller." It consists of a moldboard with a vertical shaft set so that the rotating knives carried by this shaft re-

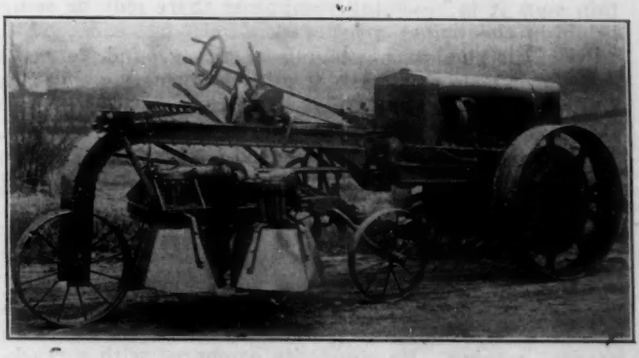


FIG. 15—A SPECIAL PLOW WITH A VERTICAL SHAFT AND ROTATING KNIVES

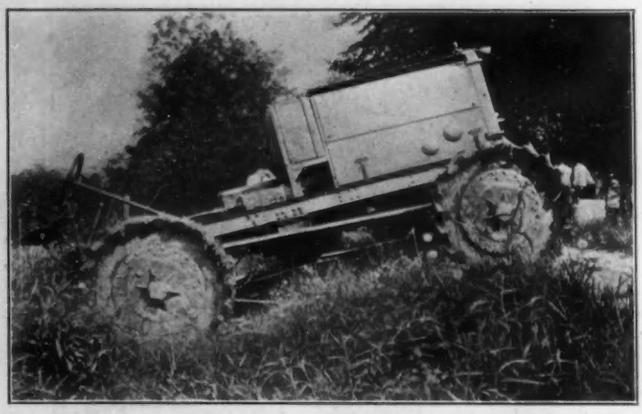


FIG. 16—A FOUR-WHEEL-DRIVE TRACTOR CLIMBING OUT OF A DITCH

ceive the furrow as it leaves the moldboard and thoroughly slice, mix, chop and pulverize it. A general view of a two-bottom complete implement of an early type is presented in Fig. 15. The moldboards with their knives are shrouded to avoid the throwing of any rocks or roots which may be encountered, and to prevent men and animals from coming into contact with knives.

For years the large implement manufactures have told their customers that fields should be disked and harrowed before plowing to provide a mulch which will tie the top soil to the lower earth, prevent air spaces

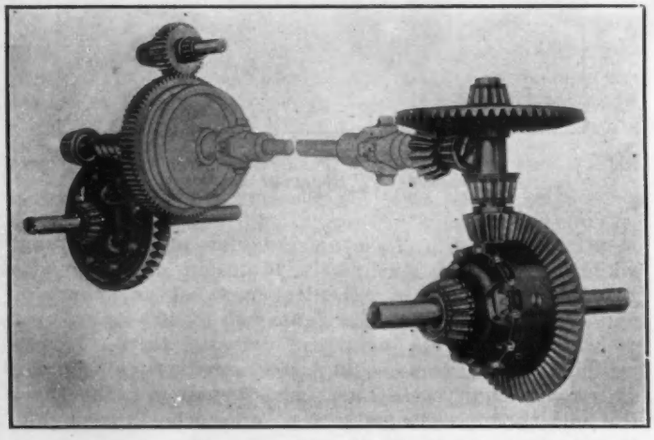


FIG. 17—THE POWER TRANSMISSION ARRANGEMENT OF THE FOUR-WHEEL-DRIVE TRACTOR

and pull up the moisture. We used to think that they merely wanted to sell us more implements, but for certain soils it is becoming recognized there may be something in the points mentioned.

In connection with packing of the ground versus a loose seed-bed, of course the track-layer type has the advantage of all other tractors in this respect as well as in adhesion. The four-wheel, or multiple-wheel, drive, comes next and owing to the advantage of such types in regard to "sand-proofness" it is believed that there is a large intermediate field for them.

One company builds a four-wheel machine which not only drives, but steers, on all wheels, steering being effected by swinging both cast-steel axles, which carry in integral housings, automobile-type differential bevel-gear sets transmitting power to the wheels through internal gearing. Its simplicity compared with a track-layer is noticeable. Both the engine and the frame are three-point suspended. In Fig. 16 this tractor is shown in a wet ditch in a position in which two-wheel machines generally come to rest and remain. The four-wheel outfit easily pulls itself out of such a hole by reason of the adhesion afforded by the forward driving wheels.

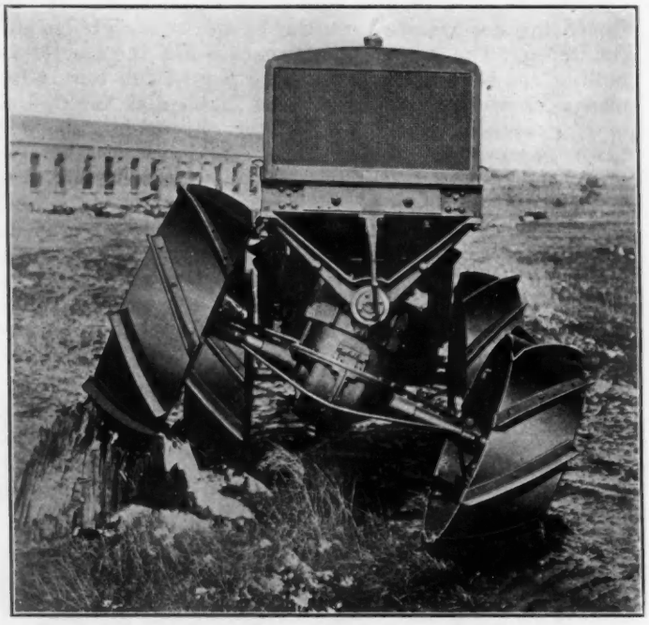


FIG. 18—THE THREE-POINT SUSPENSION OF THE FRAME

The method of applying power to the front and rear axles of a four-wheel tractor which steers on the front wheels only is shown in Fig. 17, while in Fig. 18 the three-point suspension of the frame is illustrated together with the housing of the front-axle drive.

There is still room for much development in the satisfactory steering of four and six-wheel drives. Fig. 19 illustrates an experimental type of the latter developed by the International Harvester Co., harvesting hemp in very soft and sticky ground in a very satisfactory manner.

Having now seeded the flax, operations have arrived at May 1, on the chart of Fig. 1, in Field B. The next

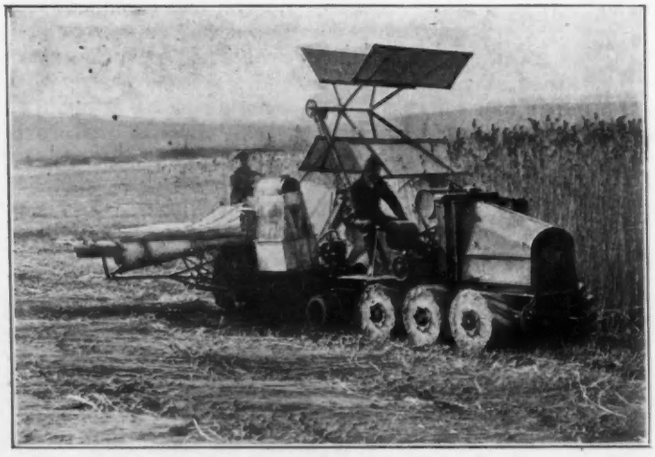


FIG. 19—AN EXPERIMENT SIX-WHEEL-DRIVE TRACTOR HARVESTING FLAX

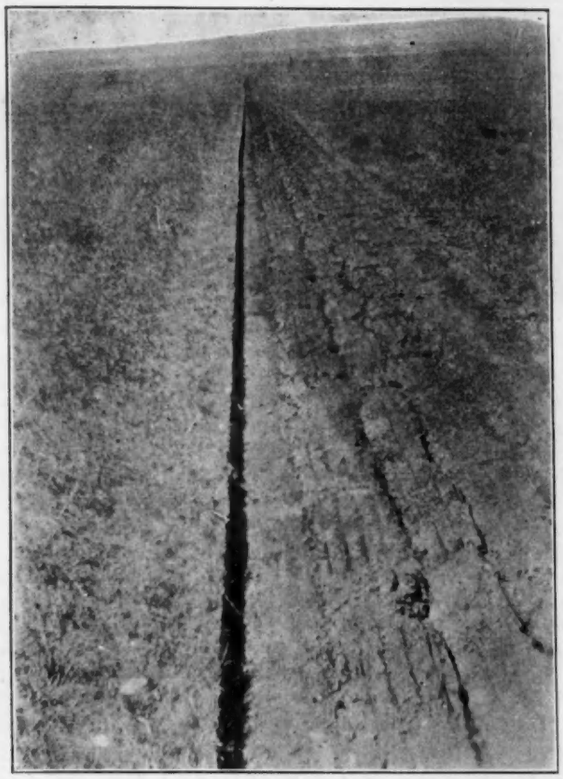


FIG. 20—A FURROW 3½ MILES LONG

step is to begin plowing, disking and packing or harrowing the 12,000 acres for winter wheat. To one who takes pride in good workmanship the laying out of the first furrow is a matter of some importance. It should preferably be done by setting stakes every 100 or 200 ft. apart; then with a careful operator at the wheel always keeping some sight on the tractor in line with two stakes, a furrow such as that of Fig. 20 may result. This particular furrow is about 3½ miles long and

FIG. 21—MOVING THE KITCHEN AND BUNK HOUSES WITH A TRACTOR

the crew, with good luck, can almost make two round-trips between breakfast and lunch time. After opening center furrows on various headlands one or two tractors may be put on each and solid routine work begun. Occasionally in some remote part of the field it is desirable to establish a temporary camp, and this is easily done by hooking a kitchen and a couple of bunk-houses, all suitably mounted on 6 by 6-in. skids, to tractors and proceeding to the new location as shown in Fig. 21.

TYPES OF TRACTOR CONSTRUCTION

It will be noticed that the frame of the machine illustrated in Fig. 22 is built of bar steel and consists of numerous different members. Owing to careful construction and fitting, however, it gives excellent service.

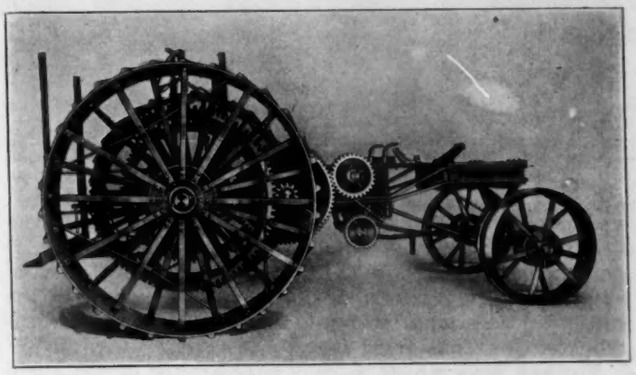


FIG. 22—A TRACTOR WITH A BAR-STEEL FRAME

The other extreme is illustrated in Fig. 23, which shows the one-piece cast-steel frame of the 10-ton Army caterpillar tractor. An intermediate type with frame built up of steel plates and angles appears in Fig. 24. In this machine the powerplant consists of six 7¼ by 9-in. vertical cylinders and is rated at 90 hp. at 500 r.p.m. In real machine design and careful construction it compares

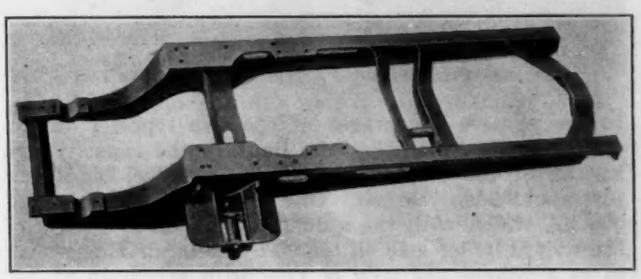


FIG. 23—A ONE-PIECE CAST STEEL FRAME

favorably with a locomotive and is a real joy to look at and operate.

A vertical engine should be provided on at least one side of the crankcase with handholes large enough to permit the removal of the piston, and there must be sufficiently large openings on the other side to admit the hands and arms. Many engines are deficient in this respect. Trying to take out a shim and tighten up big-

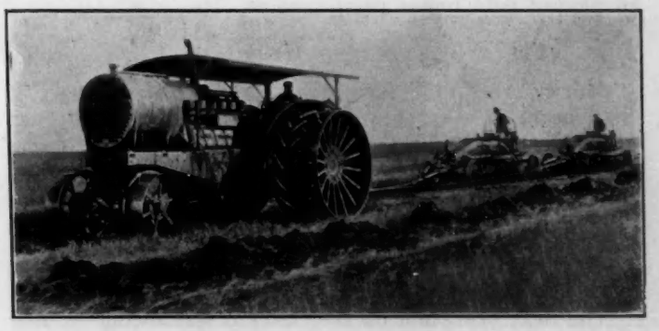


FIG. 24—A TRACTOR WITH A FRAME BUILT UP OF PLATES AND ANGLES

FIG. 27—PANORAMA OF BATTERY OF HEADING

end bearings by putting one's arm around a hot connecting-rod and crank blindly, and from the far side, is not conducive to close adjustment; and the time consumed in trying to get a slotted nut in line with the cotter-pin hole, and inserting the pin, is simply incredible until one has tried it.

For any work where there is hard ground or sod available for adhesion, and packing of the soil is no objection, the round-wheel tractors, due to their lower first cost and absence of track upkeep, are superior to the track type. Without entering into the controversy as

FIG. 25—PLOWING AND PACKING 375 ACRES PER DAY

to the relative advantages of the two types, I am inclined to the belief that the limit in the capacity and weight of the two wheel-drive round-wheel outfit has just about been reached. One such tractor weighs 23,000 lb., which with the assumption of three-fourths of the weight under load on the 90 by 36-in. driving-wheels gives a weight per inch of rim, with extension of 240 lb., or approximately 34 lb. per sq. in. of ground area, with 7 in. of the driving-wheel circumference in contact. Another weighs 28,000 lb., has 84 by 42-in. wheels, with extensions, and under the same assumptions carries 250 lb. per in. of driving-wheel width. Assuming 6 in. of the wheel circumference to be in contact with the ground, this is approximately 42 lb. per sq. in. The largest tracklayer weighs 28,000 lb., equivalent with a 24-in. track, and 85 per cent of the total weight on the track, to 495 lb. per in. of width but less than 5 lb. per sq. in. of ground-contact area. The relative packing of a plowed field under these two conditions is obvious.

PLOWING AND HARROWING

During this digression from the operating chart it will be supposed that plowing and packing have been carried on from May 1 to June 1 by the larger units. A view of such actual operations is presented in Fig. 25 in which the thirteen tractors shown have a theoretical plowing capacity of 620 acres per 20 running hr. In practice we may expect to find that at the end of the month the average daily rate per two 10-hr. shifts has been 60 per cent of the above, or 375 acres.

The next operation on the chart is harrowing in field B from June 1 to July 15. If heavy rains have occurred, it may be necessary to use disks also, and the larger outfits employed, to perform this operation more expeditiously. Fig. 26 is a rear view of a 120-hp. tractor coupled to 50 ft. of double-engine disk and spike-tooth harrows. Each such equipment, with one or two men, is capable theoretically of covering 270 acres every 20 hr. A special type of hitch is used for these outfits as the commercial form of hitch is entirely too light for such extraordinarily heavy service and had to be reinforced throughout with heavier links, draw-rods, pins and tubing. After a satisfactory hitch has been produced there was no delay whatever directly chargeable to the usual width of cut.

HARVESTING

Further reference to the operation chart will show that the next step is that of harvesting flax. This being a well-known process and no new or novel methods having been evolved for handling this crop, it will not be considered further here, and the harvesting of wheat, beginning Aug. 15 and extending to Sept. 1, 1921, in field B, or, as shown on the lower part of field A operations, 1920, labeled Flax, will be reviewed.

Ever since grandfather's time it has been carried on in the manner illustrated in Fig. 27. Here we have a bunch of headers which, as is well known, cut or head the grain and deliver it by drapers or conveyor belts into the header wagons driven alongside. If the grain is not thus delivered in the heads into the wagons, it is cut lower down, tied in bundles, and dropped on the ground.

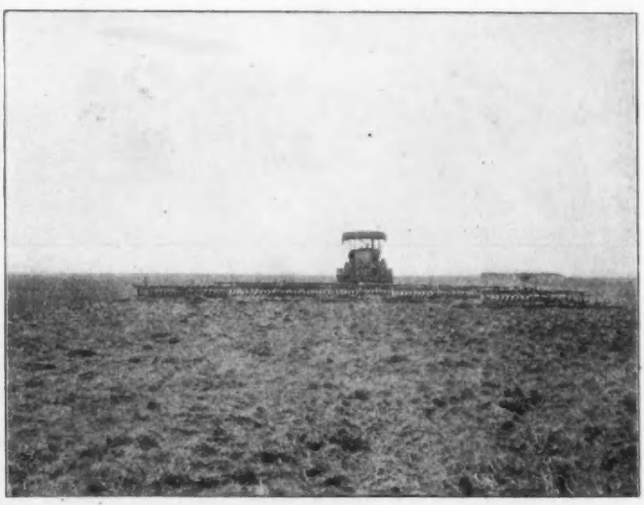


FIG. 26—A 120-HP. TRACTOR PULLING 50-FT. OF DISK AND SPIKE-TOOTH HARROWS

MACHINES EACH DRAWN BY SIX HORSES

The complete outfit shown comprises six headers cutting 10 ft. each with a theoretical 10-hr. capacity of 145 acres; twenty-four horses for headers; six men for headers; eight to fifteen header wagons, depending upon the distance to the stack; eight to fifteen drivers for header wagons; sixteen to thirty horses for header wagons; one to two men per wagon to distribute the load as received from header, total of six to twelve men; and five to six men at the stack to unload; a total of forty to fifty-four horses and twenty-five to thirty-nine men.

When such an outfit leaves camp in the morning at the same time the engine crews leave, it will require about 1 hr. to walk 2 miles and hitch up, and while there is less delay due to machine trouble in such equipment compared with combined harvester and engine equipments, the time required to get to and from the field is greater and the time lost by the ever-continuing change in the large number of men employed, due to fatigue, layoff, sick and overheated horses, waiting for header wagons, etc., and the 2-hr. time commonly lost at noon in feeding and watering the stock, will generally

FIG. 28—THE HEADER SIDE OF A COMBINED HARVESTING AND THRESHING MACHINE

place the actual running time in favor of the tractor-operated outfits.

When all this effort is expended, the grain has simply been cut and hauled and put in the stacks. To get it to the railroad the stack must be torn down, fed by hand to stationary threshers and the grain received from the threshers by wagons which must then haul it to the railroad.

In Fig. 28 is shown the process whereby the grain is being cut at the left of the tractor, automatically delivered into a so-called combined harvester behind the tractor, where it is threshed, recleaned and loaded into a wagon, hauled by the tractor itself, which need only be detached, coupled into a tractor train and hauled to the point of delivery to complete the entire process of harvesting in one trip over, even to the operation of scattering the straw back on the field or dumping it in piles. These outfits cut 24 ft. wide each. It will be observed that but three men per outfit are required, a total of nine. This battery of three cuts 8.7 acres per mile of travel, which, in 12 running hr. is a total of about 72 miles, or 200 acres. At 10 bu. per acre and $2 per bu. they will deliver into the wagons, Fig. 29, $4,000 worth of grain per day. This may be compared with the horse-harvesting method previously described where forty to fifty horses and twenty-five to forty men are required to simply get 145 acres into the stack.

Fig. 30 is a general view of the delivery side of the type of sacking machine used in the Far West. All the machinery is driven from the engine carried across the frame at the front end. Running to the upper deck will

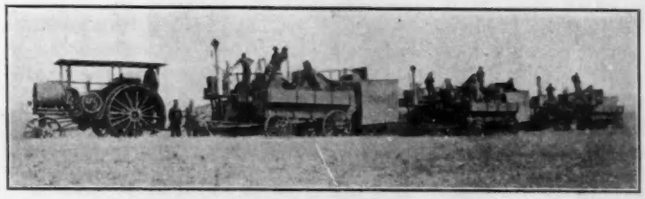


FIG. 29—THE DELIVERY SIDE OF A COMBINED HARVESTING AND THRESHING MACHINE

be seen a closed conveyor terminating in a two-way spout. Sacks are attached to these spouts and while one is filling the other is removed, sewed up and thrown down the chute at the right, which, when loaded with five sacks, is opened at the lower end, the sacks being discharged closely together. Thus trucks can drive along at right angles to the path of the harvesters and stop once only for every five sacks instead of at each sack.

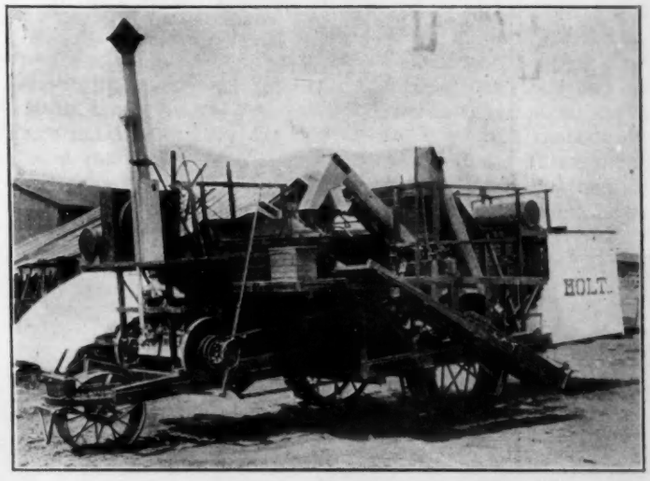


FIG. 30—A GENERAL VIEW OF A MACHINE WHICH CUTS THE GRAIN AND DELIVERS IT IN SACKS

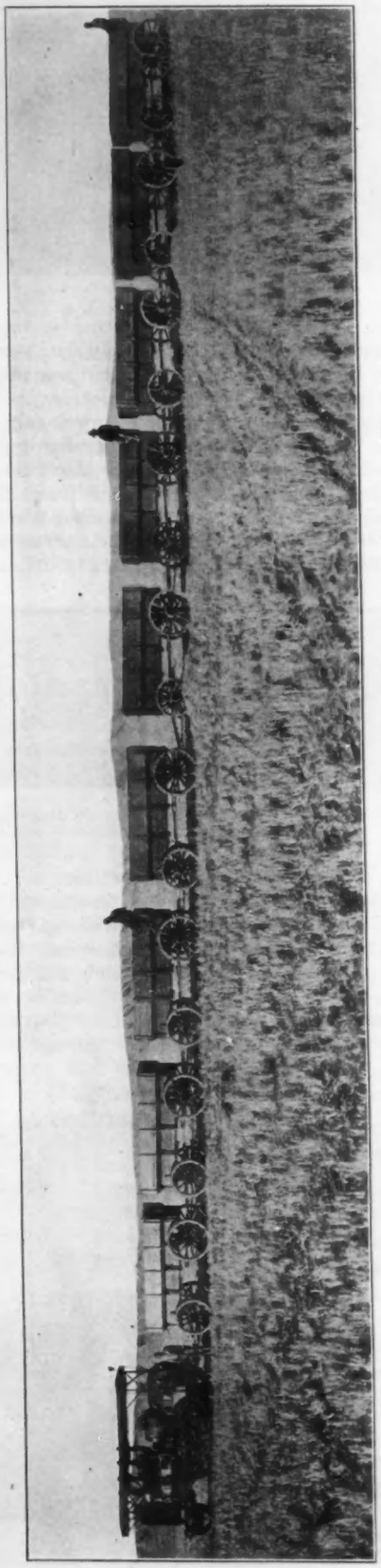


FIG. 32—A TRAIN OF NINE WAGONS BEING HAULED FROM THE FIELD TO THE ROAD BY A TRACTOR

HAULING

Tractors when not spring mounted cannot be considered for real, constant, dependable, heavy-duty road service on hard or even fairly hard roads. Even spring-mounted tractors and unsprung wagons should not be operated over 2.25 or 3 m.p.h. if long life is desired. Experience with unsprung tractors shows that wheel rims crack through, spokes break off at the bends or rivet-holes, threaded piping breaks off at the threads, copper piping cracks at couplings, every nut in the wheels, frames and engine not positively locked fast jars off, and radiators, lamps, lubricators and roofs simply go

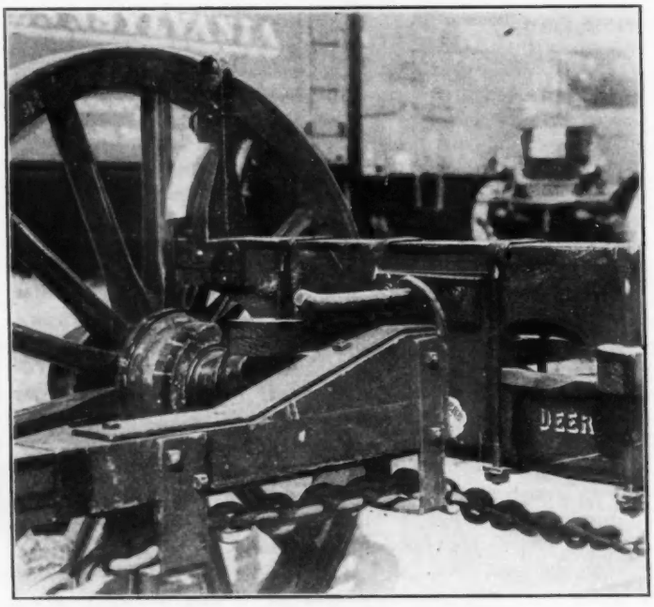


FIG. 31—DETAIL OF STUB-POLES, BUMPERS, ETC.

to pieces. A tractor must haul its train through the worst average condition. If very soft roads or grades are encountered the train must be split up and the various sections hauled by or up separately. This leads at once to the question of recoupling such a train if it cannot be backed up.

In the first place, of course, the drawbar pull from a heavy tractor cannot be transmitted through any existing type of farm wagon at the head of a train to those at the rear. Each wagon must have applied to it only the force necessary to pull it alone. This can be accomplished by running a chain from the tractor to a flat steel ring bolted to the front axle of the front wagon. From the back of the ring a chain runs to the front of a similar ring on the front axle of the next wagon, and so on. Each wagon is provided with the stub or engine pole shown in Fig. 31, carrying bumper blocks and plates and a long steel link which may be hung over the horn or pin bolted to, and projecting backward from, the rear axle. Thus the wagon tongue has no tension put upon it but merely steers the wagon to which it is attached, the wagons being free to move relatively to each other a little less than the length of the horns, thereby taking up the slack which remains in the chains after they have been coupled as tightly as possible. Nevertheless they generally take the curve shown under the rear axle of this figure, true to the law. as the poet puts it, that

> No force however great
> Can pull a horizontal cord straight.

In fact, unless a powerful toggle-link is provided and the towline is pulled up very tightly, there will eventually develop so much slack that the stub poles will come off the horns and drop to the ground, although they generally prefer to go through the spokes in the rear wheels. In either case the train is hung up for some time and where the road is so narrow that the tractor cannot get alongside the first section to pull up the back section, very serious disarrangement of the schedule follows. A through cable running the entire length of the train, which has the advantage of being lighter, can be used instead of a chain, by attaching to such cable, by pairs of clips, short "crotch chains" which run to the front axle of each wagon near each wheel. The axle rings are then eliminated.

When the train is uncoupled on the road and the sections must be drawn together again, this can be done by attaching a cable to the front of the section, passing it through a snatch block hung under the rear axle of the forward section, temporarily lashing the tongue to the cable, to steer it, and attaching the cable to the tractor alongside the forward section.

Fig. 32 shows some of these wagons being pulled out of the field onto a road. However, even the most carefully built wagons designed for horse service are hardly suitable for the heavy-duty road haulage which the advent of the tractor permits, and generally they are provided with tires that are entirely too narrow except for very hard roads.

Some of the difficulty encountered in tractor haulage is due to the fact that on many tractors, especially the smaller ones, no provision is made for attaching a load at the height of the average wagon axle. Generally the only drawbar is 12 or 14 in. from the ground. This puts

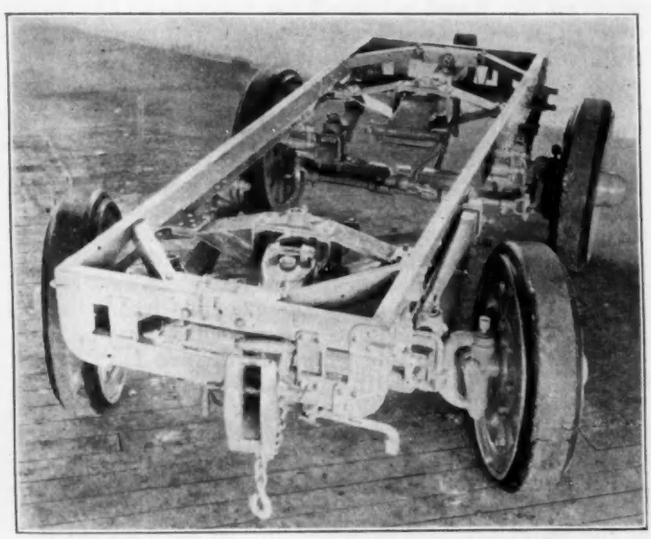


FIG. 33—A HIGH-SPEED TRAILER

an appreciable percentage of the drawbar pull vertically on the front wagon axle and assists considerably in pulling it down into the ground.

A train of modern road wagons should be capable of being hauled from either end, uncoupled at any wagon, backed up without buckling, tracking each other around turns and taking abrupt vertical bumps or ditches without breaking couplings. Some of the details by which this performance is accomplished are shown in Figs. 33 to 35 inclusive. The first gives a general view of a 5-ton

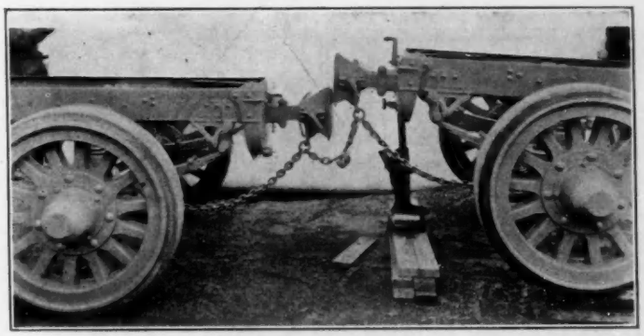


FIG. 34—HOW THE DRAW-HEADS CAN BE DISPLACED WITHOUT BECOMING UNCOUPLED

trailer good for 30 m.p.h. The drawbars can be locked on center for backing or allowed a wide range of lateral movement. At the inner end of each drawbar are yokes which, extending downward, are coupled through hinges to the steering-rods. Thus springing of these rods by vertical chassis movement is eliminated. Each drawhead carries in its jaw a horizontal pin which in turn carries one end of a pair of links. These links are hinged at their outer ends by a vertical pin, thus providing some lateral flexibility even with the drawbars locked at the center. The action of these links in a vertical plane is illustrated in Fig. 34.

Considering the fact that in railroad service where the cars are always of course lined up by the rails, automatic couplers are provided not only for the drawheads, but for the steam, air and signal hose and light and power circuits, it would seem that at least semi-automatic coupling of wagon trains should be developed, such coupling by hand being generally so difficult. In Fig. 35 one type of such device is shown. The downwardly inclined handle on the rear of the motor truck opens the pair of jaws which swing on the two heavy vertical pins shown. If the drawbar be placed in the guide or slot, and the truck backed up, the ring on the end will engage with a trip in the throat of the coupler and the jaws will spring together and lock. The time and energy saved by such modern road equipment compared to that evolved from horse-drawn service will be evident at once. If there is sufficient hauling to be done to warrant the purchase of such dependability as this type of rolling stock provides, a reasonable degree of regularity of tractor train service can be assumed.

A 120-hp. tractor or two 60-hp. units in tandem would have a drawbar pull of about 12,000 lb. at 2¼ m.p.h., and should have a high speed not exceeding 3 m.p.h. for the light return-run. With the wagons just described on 10-in. tires the rolling resistance can be taken at an average maximum of about 200 lb. per ton on a reasonably hard road with stiff mud on top, so that the above mentioned motive power should be able to haul 60 tons of total weight. Such wagons weigh about 2 tons each, how-

FIG. 35—A SEMI-AUTOMATIC TRAILER COUPLER

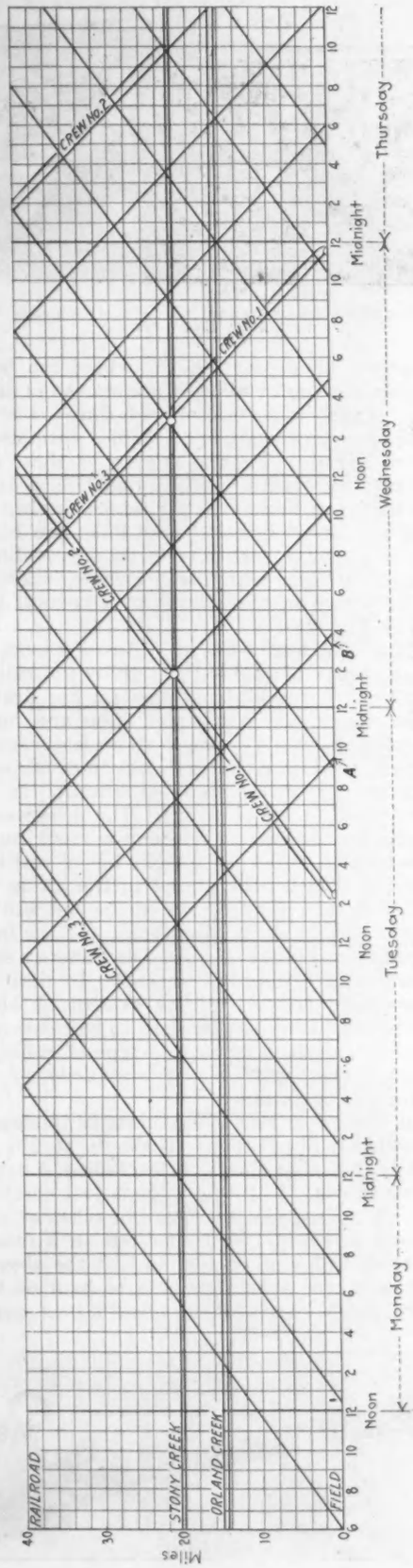


FIG. 36—THE TRACTOR TRAIN DIAGRAM

ever, so that a train of ten would weigh 20 tons, leaving a live load of 40 tons of grain.

TRACTOR TRAIN DIAGRAM

The time required for a round-trip, according to the train diagram reproduced in Fig. 36, can be segregated somewhat as follows:

Outward Bound	Hr.
Straight run of 40 miles at 2 m.p.h.	20.00
Creek crossings, uncoupling, coupling up, etc.	1.25
Three intermediate stops, oiling and loading up, ½ hr. each	1.50
Dumping and weighing	0.75
Oiling and loading up at railroad and changing crews	0.50
Allowance for engine and wagon trouble	1.00
Meeting and passing other tractors and wagons	0.50
Total time from leaving field to dumping load and starting on return trip	25.50
Inward Bound	Hr.
Straight run at 3 m.p.h.	13.4
Three intermediate stops	1.6
Engine and wagon trouble	0.5
Meeting and passing other tractors and wagons	0.5
Loading all wagons at field and loading and oiling tractors	1.0
Total time from leaving railroad, loading grain and starting for railroad again	17.0

Thus it is seen that the tractor trains on this particular job can reasonably be expected to make the round-trip every 42.5 hr.; at least it would be possible for them to do so with good luck and suitable weather conditions.

Consider Crew No. 1 leaving the field at 2:30 p. m. Tuesday, as shown on the train diagram. They will proceed at 2.25 m.p.h. to Stony Creek, arriving about 2 a. m. Wednesday. At this point Crew No. 1 is relieved by Crew No. 2 and is laid off for about 12 hr., or until 3 p. m. Wednesday, at which time a returning empty train will be due at Stony Creek, its crew, No. 3, being ready to lay off for 12 hr. Crew No. 1 will therefore take this train back to the field, arriving at 11:30 p. m. Thursday.

It may be thought at first sight that loaded wagons should be substituted for empties at the field, and the incoming tractors started back immediately upon their arrival. If this is done, however, it will be seen that owing to the difference in speed between the incoming and outgoing trips, the trains will not meet at a constant passing point, as at Stony Creek for example, where bunkhouses, a small repair shop and a loading station are established, and men and supplies will then have to be carried back and forth in automobiles with much lost time as a consequence. Furthermore if a train is supposed to leave as soon as it arrives and if that train is delayed in arriving, the entire schedule of meeting points and crew exchanges is displaced, and the trains are liable to bunch up, overtaxing loading and unloading facilities at the respective ends of the haul. By allowing an interval somewhere in the round trip, that is at headquarters, with its repair shops and extra men for despatching a loaded train just before an empty is due, a train arriving at 9:30 p. m. Tuesday, as at A, and due to leave at 3:15 a. m. Wednesday, at B, has a leeway of about 5½ hr., the headquarters crew can give it their entire attention, the inevitable repairs can be made, the outfit loaded, and, unless the delay has been very serious, the schedule maintained.

The rate of delivery for the large units would be 40 tons of grain divided by the elapsed time for one round-

(*Concluded on page* 185)

War Department Motor Transport Policy

By Brigadier-General C. B. Drake[1], U. S. A. (*Member*) Semi-Annual Meeting Paper

IN view of the inestimable services which the Society has rendered to the Army in the past, and particularly during the stress of war, in the development of standardized transportation, I believe it most important that you should be acquainted with the intentions and policies of the War Department regarding the engineering development of motor transportation from the point of view of the problems and needs of the American Army. Nearly a year and a half ago, in February, 1919, Lieut.-Col. Orton of the Motor Transport Corps delivered an address[2] before the Society at New York City, entitled the Motor Transport Corps and the Automotive Industries. In this address Colonel Orton quoted a memorandum from the Chief, Motor Transport Corps to the Chief of Staff, presenting what were then conceived to be the fundamentals of our policies on motor transportation. This memorandum received the approval of the Chief of Staff. The following extracts from the memorandum may again be quoted to you:

POLICY OF STANDARDIZATION

Standardization of Chassis The Motor Transport Corps recommends equipping the Army with only standardized chassis, designed specifically for military service, and for limiting chassis models to the least possible number required by the services to be performed

Body Designs The Motor Transport Corps recommends that all special bodies needed by the various services of the Army be designed in conference with Motor Transport Corps engineers, to apply to one or the other or the standardized chassis

Engineering Division The Motor Transport Corps proposes to maintain its Engineering Division under able leadership, and to charge it with the duty of keeping the standardized military models abreast with the progress of the times. The facilities available in the Motor Transport shops will make this work possible at the minimum expense

Subsequent Changes

Since the time when this address was delivered several new factors have been introduced into the situation. In the first place, by the Army Reorganization Bill recently passed by Congress, the Motor Transport Corps has been consolidated with the Quartermaster Corps of the Army. It is too soon to state exactly what will be the effect of this consolidation, but it is safe to state that there will be no interruption in the functioning of the motor-transport activities of the Army, whether of design, operation, or repair and supply. The achievements of the Corps in the late war, and the immense and increasing importance of motor transportation in a modern army, are guarantees that the work begun in the past will be carried on along the general lines on which we have started, and without interference. There is no doubt in my mind that the Quartermaster Corps will give the heartiest co-operation to such development. This point is therefore mentioned only because it is desirable to remove any idea which may be held that the importance of motor-transport development is under-estimated, or will in the future be hindered, in any way, no matter what the title of the organization which carries the work forward.

It has been appreciated by the Motor Transport Corps and the General Staff that any policy regarding the types of vehicle to be used during the war must necessarily turn on the production abilities of the country; and a detailed investigation has been made into this point. The entire army has been for the past one and one-half years in an unsettled state; partly because it has been necessary to liquidate our great war organization, and partly because it has until within the past month been uncertain what the new peace organization would be. The uncertainty thus produced, and the resulting tentative quality of any plans made, have been reflected in the Motor Transport Corps as elsewhere, and in considering the development of the above-mentioned policies in the past one and one-half years this point must be borne in mind. With this preliminary I will state briefly the present status and policy of the Corps as regards the fundamental engineering problems.

Standardization of Chassis

The arguments for and against standardized chassis are familiar to this Society, and it is not necessary to repeat them in any detail. Briefly stated, the Army desires standardized chassis because (*a*) they simplify the tremendous maintenance and spare-parts problems; (*b*) they will necessarily conform more closely to military requirements than chassis designed for commercial use and (*c*) for simplicity of operation. Of the arguments against standardized chassis, the only vital one is that which raises the question of production. Can such chassis be obtained in quantity in peace, and especially in war?

In taking up this problem, three things are obvious.

(1) Our peace army will never be more than a small fraction of our war army. It is improbable that our military policy will allow the accumulation of very large stores of reserve equipment such as trucks in time of peace

(2) A complete and unqualified standardized program for war is therefore impossible, for immediately upon the declaration of war we will require great quantities of vehicles which must be obtained at once, and which we cannot wait to manufacture

(3) How soon after the declaration we can obtain standardized vehicles in quantity, must then be one of the deciding factors in the adoption of a standardized program; and it is a question which the industry alone can answer

With the purpose of investigating this last point, computations were made in this office as to our demands for motor vehicles in war time; and through the courtesy of the National Automobile Chamber of Commerce, a questionnaire was circulated to the truck manufacturers of the United States, from the answers to which we hoped to be able to form an estimate of what can be done.

It is impossible to give a detailed analysis of the war-time needs, for that would involve the publication of cer-

[1]Chief, Motor Transport Corps, Washington.
[2]See The Journal, April, 1919, p. 234.

tain of the confidential plans of the General Staff. It can be stated, however, that there are two estimates of the quantities of trucks, considering these only, needed, for a war such as the one just closed, drawing fully on our man-power. This first is 80,000 for the first five months, and 60,000 for the succeeding year. The second is 40,000 for the first five months, and 100,000 for the succeeding year. It is my personal opinion that the second estimate is much more nearly correct. In any case, it is the safer one for our computations, and will be adopted.

It is the general opinion of production experts of the automotive industry who have been in touch with our work in the past, that assuming all the designs have been worked out, that most of the assemblies of our standard trucks are commercial assemblies, that tools, jigs and fixtures are on hand for the others and a definite plan of production in existence and, what we can always count on, the cooperation of the industry, standardized trucks can be put into quantity production in from four to six months after the outbreak of war; the period of five months is taken as a mean. It follows from the above figures that our problem is that of obtaining 100,000 standardized trucks, in the period from five months after the outbreak of any war to seventeen months after the outbreak.

Turning now to the question of the extent to which we can count on production of standardized trucks, this depends on two factors. One is the character of the assemblies used. The standardized vehicles designed during the war were composed principally of assemblies which were also specially designed for Government use. This was considered necessary for the reason that the manufacture of parts and assemblies suitable for military use had not then progressed to the extent that it has now. The great development of this branch of the industry in the past two or three years has led the Corps to believe that satisfactory standardized trucks for military use can be constructed, using almost entirely standard commercial assemblies which are already in quantity production. It will be the policy of this Corps in any future designs or redesigns of standardized trucks to utilize as far as possible standard commercial assemblies. The facilities for quantity production of such assemblies are so great that we have nothing to fear in this line. We must therefore consider the second factor, which is the ability of truck manufacturers to assemble the standardized trucks.

The replies to the questionnaire previously referred to were received some weeks ago and have been carefully analyzed. The analysis discloses the following points:

(1) Out of twenty-nine companies consulted, eighteen were in favor of standardization, three expressed no definite opinion, and eight were against it

(2) Inquiry was made as to the quantity of standardized vehicles which could be produced in one year, after quantity production was started, with spare parts under war conditions, assuming tools and fixtures on hand. Of the eighteen companies in favor of standardization, their estimates, taking average figures throughout, totaled around 80,000 vehicles. Of the three companies not expressing any definite opinion, their estimate totaled 13,000 vehicles. Of the eight companies opposed, their estimate totaled 59,000 vehicles. Of this last figure nearly two-thirds came from one company, and for this and other reasons, this last estimate is considered rather uncertain. It would certainly be safe however to count on 25,000 to 30,000.

We have then the sentiment of a large majority of the industry in favor of standardization and an estimate of production possibilities aggregating considerably more trucks than we will need, even under the less favorable of the two estimates given above, for the critical period beginning five months after the outbreak of war and extending for a year thereafter. This strikingly satisfactory response of the industry confirmed the Motor Transport Corps in its opinion of the desirability of the standardization program. But, as stated, it must be supplemented in some way to fill the great demand for vehicles, totaling 40,000 by the above estimate, in the months at the beginning of war before quantity production of standard vehicles can be begun.

Government Standardized Trucks

The policy recommended by the Chief, Motor Transport Corps is therefore that Government designed standardized trucks be adopted as standard for the Army. These are to be designed by the Engineering Branch of the Motor Transport Corps, with the assistance and cooperation of this Society and of the industry as a whole. Standardized trucks are to be manufactured for the Government in time of peace in such quantities as are necessary for replacements. The quantities so needed cannot be told precisely but will probably amount to several thousand a year. On the declaration of war, arrangements will be made with those elements of the industry which are most suitably equipped for the work, to start at once on the production and assembly of standardized vehicles. Quantity production on them will be pushed to the utmost with a view to equipping the army with these trucks in the critical period beginning around five months after the outbreak of war, when the great bodies of newly organized troops, demanding tremendous quantities of equipment, are beginning to appear on the field of battle to supplement our first line.

In the meantime, to fill in the gap before quantity production begins, there will have been prepared in time of peace an "Alternative Standard List," consisting of those commercial vehicles which by peace-time tests have been shown to be most suitable for Army requirements. It is desired to hold such tests from time to time, perhaps yearly, and to invite all builders of trucks to compete in them. On the basis of the tests, a limited number of makes of truck will be approved as alternative standards for Government use, and satisfactory for purchase and use in the Army until the standardized vehicles are available. It is these trucks we would purchase, or commandeer, or both, at the beginning of war, in sufficient quantities to fill our immediate needs and equip the first units of our armies.

The approval and development of this general policy will necessarily require much time. I believe, however, that I am safe in saying that the main outline as given above will remain unchanged.

It will be noted that mention has been made specifically of trucks alone. By far the most important element of our standardization program is that concerned with trucks, and it is the one on which the Motor Transport Corps desires to concentrate all its efforts in the immediate future.

Body Design and Parts Specifications

The standardization of body design is a matter of great importance to the Army, but of much less importance to the industry than the first question. Of the number of bodies for cargo and special motor vehicles designed and constructed for the Army during the war, there were few, if any, which presented peculiar problems of construction calculated to embarrass the manufacturer. The chief

difficulty in this line has been that there were so many varying types. This has been due to the number of different organizations in the army, interested in the design of motor vehicles for special purposes, who have proceeded with the design of bodies without adequate coordination or sufficient consideration of existing design.

The engineering branch of the Motor Transport Corps has in the past eight months developed a system of close liaison with all other branches of the service in all matters affecting the design of motor vehicles. It has given particular consideration to the question of body design, with the primary object of cutting down the number of types of body design which have in the past been adopted. This work has already borne fruit in the elimination of some forty special vehicle types heretofore on the standard list, for which have been substituted other vehicles on the standard list that can be utilized for the same purposes. Much more elimination can be effected in this matter, but an excellent beginning has thus been made.

The particular importance of this is that with a very limited number of different designs of bodies, it will be much easier to obtain large quantity production promptly at the outbreak of war, and there will be much less danger of competition in the market of different arms of the service. Body builders are thus assured of being able to give their full production facilities to the Government in time of war, with a minimum of confusion and delay attendant on departmental routine.

There are certain important parts and accessories for motor vehicles that are not integrally built-in parts of the vehicles, regarding which the policy of the Motor Transport Corps has in general been to buy commercial products in the open market. Examples are storage batteries, spark-plugs, magnetos, hub-odometers, electrical instruments, etc. The general policy of the Corps in this matter is to devise specifications for such articles which shall be principally performance tests, limiting as little as possible the initiative of the manufacturer in using any form of construction which he sees fit, provided it conforms to S. A. E. Standards, to obtain his results. Having developed such performance specifications, all commercial articles of that class can be tested under them, and from those which pass satisfactorily an approved list for purchase can be developed. No purchases will be made except from this list. It is further the policy of the Corps to permit manufacturers whose products are placed on the approved list, to utilize that fact in their advertising, suitable safeguards, of course, being used to insure the industry against any possibility of improper use of this privilege.

In developing specifications of this character it is of the utmost importance to secure the close cooperation of this Society, and of the industry as a whole. It has also been our policy to work very closely with the Bureau of Standards at Washington whose technical equipment and abilities are recognized throughout the country. Much work has already been done along this line. Satisfactory specifications have been developed for all types of automobile tires and for spark-plugs. Work is now being completed, with the cooperation of this Society, on specifications for storage batteries, and much preliminary work has been done on the question of magnetos and hub-odometers. It is hoped that in the ensuing year the most important remaining items of this class can be covered in the same manner.

At the War Department end, the Motor Transport Corps, with the approval and cooperation of the General Staff, has been attempting to make these specifications standard throughout the Army, not only for this Corps but for all other Corps or Bureaus which use the same articles. The advantage of this to commercial organizations dealing with the War Department is obvious. An excellent beginning has been made on this work and it will be pushed with vigor.

ENGINEERING BRANCH, MOTOR TRANSPORT CORPS

As stated in Colonel Orton's address over a year ago, it is the policy of the Corps to maintain a thoroughly adequate and efficient engineering branch. The policy of utilizing commercial assemblies where practicable on standardized trucks will, however, remove a great part of the load which would be thrown on such a branch if we contemplated redesigning all our vehicles from the ground up. It will still be necessary to utilize in an administrative or advisory capacity a few individuals of the highest ability, but it will not be necessary to have a plant so large and expensive that it would be beyond the power of the Government to maintain it. Such an organization as we have developed since the armistice has proved to be entirely adequate to handle our problems in this line.

In closing, I wish to express again to this Society my appreciation of the tremendous benefits which the Motor Transport Corps and the Army have derived from its assistance and cooperation. It is not necessary to review the multitudinous lines of activities in which we have worked together in the past, to our own great benefit and it is hoped with some benefit to the Society as well. It is my most earnest hope and that of the entire Corps that we may continue to work together in the same spirit in the future.

DESIGN OF SUPERCHARGED AIRCRAFT ENGINES

TECHNICAL Note No. 7, of the National Advisory Committee for Aeronautics which has been recently issued contains a translation from the Technische Berichte, Vol. III, Sec. 5, by George de Bothezat of an article relating to the design of supercharged and overdimensioned aircraft engines. In the notes it is pointed out that the purely supercharged engine must be considered as overloaded, because the increase of power with altitude reached by supercharging is limited. When climbing, the power drops very nearly as the density when the carbureter is properly adjusted and the temperature at the end of the compression will not be influenced by throttling, but the heat state of the cylinder will be reduced to such an extent that self-ignition will not take place under any ordinary conditions.

The entire gain from supercharging appears only in connection with using a larger sized engine because an oversized unit can and must be throttled down much more than the smaller sizes equipped with superchargers. The power diagram of a supercharged, and at the same time overdimensioned, engine is presented together with a simple scheme of throttling and adjustment for such an engine. An example of the calculation of the dimensions of such an engine which is simple and at the same time sufficient for ordinary practice is presented. A copy of the pamphlet can be secured upon application from the National Advisory Committee for Aeronautics, Washington.

Proposed Work of the Committee on the Science of Truck Operation

AT the Transportation Session of the Semi-Annual Meeting at Ottawa Beach, Mich., which was held on June 23, F. W. Davis, chairman of the Committee on the Science of Truck Operation outlined in a general way the work which the Committee planned to accomplish. It is proposed to divide the subject into five parts and assign one of these to each member of the Committee as follows:

Comparison of Modes of Transportation—F. Van Z. Lane
Selection of Equipment—C. M. Manly
Service Stations—E. E. Wemp
Principles of Operation—M. C. Horine
Cost of Operation—F. W. Davis

The headings are in turn divided and further subdivided as indicated in the accompanying outline. The remarks made by Mr. Davis in presenting the proposed program follow:

No individual today has to argue the important place of transportation of every kind. It is recognized that it is probably the most important phase of the activities throughout the globe. The general progress of civilization has really followed the progress in development of transportation. The phase in which we are particularly interested in this Committee is the matter of developing the highway transportation, and for a starter we have designated truck operation. The extent to which transportation is carried over the highways does not require any statement in that it is by far the most important of all the branches.

In the development of this highway transportation, motor-truck transportation in particular, we have done much toward developing the mechanical, the engineering and the technical sides. After we have built the vehicles, we place them in the hands of the users, and they go out and operate them the best they can. It is really fortunate that they have been so successful, because they received very little assistance, have had very little guidance, have had very little expert assistance and encouragement from the engineers who have had to do with the design and the construction. It has reached the point now where there is felt a great necessity for obtaining trained men, not only men who are able to assist in the production, design, manufacture and so forth of these vehicles, but also who will have to do with the operation, the proper coordination of the vehicle with the business that it goes into; furthermore, the study of the relation between the motor truck and the highway, not so much from a mechanical standpoint as from an economic standpoint.

Along with that is recognized the necessity for carrying on some very extensive research, not only on the character of pavements, the base construction, drainage in relation to highways, but also the relation between the motor truck and the highway considered from an operation standpoint, the question such as the effect of different kinds of pavement on the cost of operation, the effect of the grade on the cost of operation and various other items of that kind. To solve those problems, a conference was held at Ann Arbor a month or so ago, and out of that a further conference in Washington, at which representatives of the industry, the educational institutions and the users got together and discussed the actual needs in numbers and in scope of training necessary for the men to undertake this work, also the necessity for carrying out certain lines of research to get the best possible results. There was recognized and stated in actual numbers the men and the particular needs of the next five years in the industry and for the users. To get those trained men, it is very necessary to have the personnel and the material to train them. It is very well to say that we will train hundreds of thousands of men and that those men will be available in the course of a year or two years or five years, but we must have the material and we must have the personnel to give that training. The obtaining of the personnel is a very important problem, and efforts are being exerted along that direction right now, as most of you know, to obtain men who are qualified to take the chairs of transportation in some of the universities and carry through this training program.

Along with that was brought out the lack of actual material to present to these men who will, in turn, relay it to the students. About six months ago, I called attention to the necessity for coordinating and grouping and making available the fundamentals of truck operation to Past-president Manly. Out of that and some correspondence that followed, a small committee was designated to take hold of this problem. That committee is in existence today, and it is attempting to get under way slowly. We are feeling our way and finding out, first, what the problem is before we really attempt to accomplish anything. The Committee is a tentative group that will start to work on this subject. A meeting was called a few weeks ago, and at that time we discussed the range and scope of the subject, of building a real science out of this truck operation question. At that time, there were five headings suggested as more or less covering the general subject. Those five headings have been amplified somewhat and are given together with the subheadings under those main divisions in the accompanying outline:

COMPARISON OF MODES OF TRANSPORTATION

Horse
- Limiting daily mileage
- Loading and unloading time
- Costs

Railroad
- Fixed trackage
- Relation between loading time and running time
- Short hauls
- Less than carload shipments
- Freight rates
- Terminals

Waterway
- Route limitations
- Length of haul
- Relation between loading time and running time
- Rates
- Docks

Motor Trucks
- Flexibility
- Relation between loading time and running time
- Short and long hauls
- Delivery advantages
- Costs

SELECTION OF EQUIPMENT

Type of Units
- Trucks
  - (*a*) Solid tires
  - (*b*) Pneumatic tires
- Tractors
  - (*a*) Fifth wheel
  - (*b*) Draw head

Size and Number of Units
- Uniform
- Combinations

Auxiliary Equipment
- Bodies
  - (*a*) Plain
  - (*b*) Dump
  - (*c*) Demountable
- Loading and unloading devices
  - (*a*) Winches
  - (*b*) Cranes
  - (*c*) Roller conveyors
  - (*d*) Unit packages

SERVICE STATIONS

Location
- Selection of site
- Type of building
- Consideration of public garage

Size
- Single building
- More than one building
- In combination with public garage

Equipment
- Shop facilities
- Gasoline and oil storage
- Elevators
- Washing facilities

Personnel
- Administrative
- Mechanical force
- Other labor
- Relation between size of fleet and other headings in this group

Inspection and Maintenance
- Inspection systems
- Maintenance systems
- Relation between size of fleet and other headings in this group

PRINCIPLES OF OPERATION

Loading and Unloading
- Relation to total time of operation
- Relation to tonnage hauled
- Effect on short and long hauls
- Effect on cost of operation
- Relation to cost of auxiliary loading and unloading equipment

Routing
- Advantages of direct routes
- The zone system of distribution
- The use of substations
- Return loads

Cost Records
- Their value
- Necessary data
- Form systems

Drivers and Helpers
- Qualifications and training
- Effect of drivers on tonnage handled
- Effect of drivers on cost of operation

Time Out of Commission
- Cost of replacement parts and labor
- Money loss in failure to deliver goods
- Money loss in tieing up of other operations

Roads
- Surfaces
- Grades
- Curves
- Bridges

Truck Abuse
- Overloading
- Overspeeding
- Lack of inspection
- Deferred maintenance

Legislation
- Limiting speeds, weights and dimensions
- Lights, mirrors and signalling devices
- Federal and State considerations

COST OF OPERATION

Investment
- Outright purchase
- Deferred payment

Based on Time (Fixed charge)
- Administrative expense
- Interest
- Insurance
- Garage
- Drivers and helpers
- Taxes

Based on Mileage (Variable expense)
- Tires
- Fuel or current
- Lubrication
- Inspection and maintenance
- Depreciation

Comparisons
- Cost per ton
- Cost per mile
- Cost per day
- Cost per unit-mile
- Other combinations
- Truck efficiency

Charge Rates
- Time
- Mileage
- Tonnage
- Combinations
- Contract hauling

Earning Power
- Difference between truck costs and earning power
- Relation to size of fleet
- Effect of variations in charge rates
- Effect of variations in cost items
- Effect of variations in loading and unloading time
- Effect of variations in length of haul
- Effect of variation in loads carried

Bonuses
- Ratio of labor cost to total cost
- Items under control of driver
- Methods of applying bonus

Recording Instruments
- Justification
- Items to be determined
- Analysis of records

The outline submitted is a tentative one and is subject to revision. It is submitted as a working plan in order to get started, and it is my hope that if this Committee accomplishes anything toward bringing the subject of the economics of motor-truck operation a little bit out of the clouds and starting some thoughts toward the building of a science destined to take its rightful place in the general scheme of things, whatever effort expended will be many times justified.

Report of the Minneapolis Section Tractor Research Committee

IN arranging the program of the past season for the Minneapolis Section of the Society, it was thought that it would be very desirable to select subjects which are directly related to tractor and engine design and to have as a common topic of discussion at each meeting the Ideal Three to Four-Plow Wheeled Farm Tractor, the object being to correlate as many good ideas as could be gathered through a discussion of the subject into one composite design which would in a general way be a foundation plan of what we, at this time, consider to be the best arrangement and proper size for a three to four-plow wheeled tractor. In addition to discussing the subject in a logical and orderly manner, a ballot was arranged which enabled each member to state exactly his ideas, after the features to be voted upon had been thoroughly discussed. This scheme enabled each one to get the other fellow's reason and point of view and resulted in some very frank and thorough debate.

The "plan of attack," so to speak, was to be in the following order:

(1) A discussion of the wheel arrangement to determine the number, location, diameters, widths, type of construction, type of rim section, type of grouter equipment, type of skid-ring equipment, type of final drive as related to drive-wheel construction, type of axles, turning radius as related to wheel arrangement and size, wheel-base and wheel tread

(2) A discussion of frame constructions to determine the most suitable type

(3) A discussion of miscellaneous details as affecting the power requirement, transmission design, weight distribution, etc., namely:
- (*a*) Traveling speeds and number
- (*b*) Required drawbar pull
- (*c*) Location of drawbar
- (*d*) Range of drawbar adjustment
- (*e*) Location of belt pulley and belt speed

(4) A discussion of transmission arrangement and design with reference to materials, bearings, production, etc.

(5) A discussion of clutches to determine the preferred type

(6) A discussion of engines to determine the type, size, mounting, design, etc.

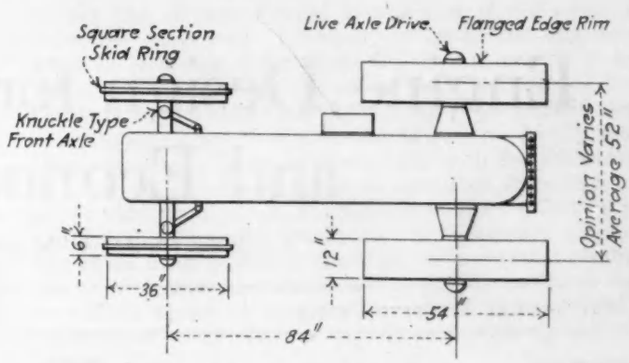
(7) A discussion of cooling systems and means of temperature control

The comprehensiveness of this plan did not permit of our covering more than about one-half of it in the past year but it has proved to be most interesting and educating. It is with pleasure, therefore, that I refer to the report of the Research and Engineering Practice Committee, of which Prof. A. F. Moyer is chairman. This report shows the vote polled in reference to each subject discussed and is shown graphically on the accompanying drawing as far as we have gone. You will observe that the four-wheeled tractor is preferred, with automobile-type front axle, live driving-axle, and belt pulley located on right side, the belt speed to be 2600 ft. per min., the weight approximately 5000 lb. and the drawbar to be adjustable.

RESULT OF BALLOTS ON THE IDEAL THREE TO FOUR-PLOW WHEELED FARM TRACTOR

Number of ballots cast		10
GUIDE WHEELS FOR STEERING		
Number,	Two	9
	Four	1
Location,	Front	9
	Front and rear	1
Diameter,	30 in.	1
	36 in.	5
	38 in.	1
	42 in.	1
	Large as possible	1
Type of Skid-Ring,	Square	4
	Angle	2
	None	1
Type of Axle,	Automobile knuckle	10
	Live	1
Turning Radius,	11 ft.	1
	12 ft.	1
	13 ft.	1
	15 ft.	2
	20 ft.	1
	45 deg.	1
	Short as possible	1
DRIVE-WHEELS		
Number,	Two	9
	Four	1
Location,	Rear	9
	Front and rear	1
Percentage of Tractor Weight on Drive-Wheels—		
	$66\frac{2}{3}$	3
	60	1
	75	1
	80	1
	100	1
	Dependent on design	1
Diameter,	42 in.	1
	48 in.	1½
	54 in.	4½
	60 in.	2
Face of Tire,	12 in.	6
	14 in.	1
	16 in.	2
Type of Rim,	Flat	3
	Flanged-edge	4
	Smooth	1
Type of Grouter,	Angle and spade lug	2
	Angle	2
	Angle and block	1
	Spade and block	1
	Dependent on conditions	1
Type of Final Drive,	Live-axle	3
	Enclosed spur-gear	2½
	Enclosed internal-gear	1
	Open internal-gear	1
	Bevel-gear	½
TYPE OF FRAME CONSTRUCTION		
Structural		5
Integral or cast		4

MISCELLANEOUS	
Wheelbase, 76 in.	1
80 in.	1
84 in.	5
96 in.	1
100 in.	2
Tread, Center to Center of Drive-Wheels—	
40 in.	1
46 in.	2
52 in.	1½
56 in.	1½
62 in.	1
Tractor Weight, 5,000 lb.	4
5,200 lb.	2
6,000 lb.	2
7,500 lb.	1
Drawbar Pull, 3,000 lb.	2
3,200 lb.	3
4,500 lb.	1
7,500 lb.	1
Plowing Speed, 1½ m.p.h.	½
2¼ m.p.h.	½
2½ m.p.h.	3
2¾ m.p.h.	3
3 m.p.h.	½
3½ m.p.h.	1½
Other Speeds, 1.6 m.p.h.	½
2 m.p.h.	1
2¼ m.p.h.	1
3½ m.p.h.	2
4½ m.p.h.	½
5 m.p.h.	1
Drawbar Location and Adjustments—	
Adjustable both vertically and horizontally	4
Adjustable vertically	1
Heights Expressed, 15 in.	½
17 in.	2
18 in.	½
Belt Speed, 2,500 ft. per min.	1
2,600 ft. per min.	3½
2,700 ft. per min.	2½
2,800 ft. per min.	1
3,000 ft. per min.	1



Weight, lb.	5,000
Drawbar Pull at Plowing Speed, lb.	3,200
Belt Speed, ft. per min.	2,600
Plowing Speed, m.p.h.	2.50 to 2.75
Height of Drawbar, in.	17
Vertical Adjustment, in.	4
Horizontal Adjustment, in.	18

THE IDEAL TRACTOR FAVORED BY THE MINNEAPOLIS SECTION

Pulley Location, Transverse shaft	1
Either side	3
Right side	4
Height and Belt Clearance Important	2

A. F. MOYER, Chairman,
Research and Engineering Practice Committee,
Minneapolis Section, Society of Automotive Engineers, Inc., 1919-20.

We have only completed what might be called the foundation plan. Next season we shall carry on the discussion with reference to the other features of design, so that within a year from now we should be able to draw a definite picture of the Ideal Three to Four-Plow Wheeled Tractor.

Respectfully Submitted for
THE MINNEAPOLIS SECTION,
Society of Automotive Engineers, Inc.,
By A. W. Scarratt, Chairman.

THE KILN DRYING OF WOODS FOR AIRPLANES

A BRIEF discussion of all of the fundamentally important phases of the subject of kiln drying lumber specifically for use in airplanes is given in Report No. 65 of the National Advisory Committee for Aeronautics.

The exigencies of the war and scarcity of air-dried material necessitated kiln drying stock immediately from the green condition. Exhaustive experiments and tests made by the Forest Products Laboratory during the last ten years have established the fact that properly kiln-dried wood is just as strong, tough, and stiff as the best air-dried material. Douglas fir wing beams may be dried in eighteen to twenty-four days. To air dry the same material requires twelve to eighteen months. Hardwood propeller stock which requires a year or more for air drying may be satisfactorily kiln-dried in thirty days. The important qualities of dried wood are freedom from checks, honeycombing, or case hardening; uniform moisture distribution; maximum strength and toughness; freedom from collapse and warping and minimum shrinkage. The microscopic structure of wood is briefly described, also the way in which moisture is contained in wood and the properties and behavior of wood upon removal of moisture. Methods of controlling the circulation, humidity and temperature in the various kilns are discussed; also the use of instruments for determining actual conditions within the kiln. The method of piling the lumber within the kiln has much to do with the factors of circulation and control of conditions. To know what is taking place, a suitable method of sampling and testing the material during the progress of drying must be instituted, and definite records kept of the process. These points are fully discussed. Methods for removal of case-hardening and prevention of mold are described.

Three articles are added in the appendix. The first is the Signal Corps specifications for kiln drying airplane stock, with an introduction explaining its origin. These specifications were prepared on July 2, 1917, by the Forest Service and have been employed without significant changes. The second article presents a constant dew point schedule for Douglas fir, spruce and similar woods. The third is a brief description of the water-spray dry kiln designed by the Forest Products Laboratory and used in the tests referred to.

A copy of this report can be obtained upon request from the National Advisory Committee for Aeronautics, Washington.

Engine Design for Maximum Power and Economy of Fuel

By C. A. NORMAN[1] (*Member*)

SEMI-ANNUAL MEETING PAPER *Illustrated with* CHARTS

THE present paper is only one of a symposium and will therefore deal with the subject from a narrow angle only, that of thermodynamic reasoning. Several factors affecting power and economy cannot be dealt with on this basis, nor on this basis alone. Power and economy are closely connected for instance with the question of knock. The publications of Messrs. Kettering and Midgley show the phenomena of knock to be perhaps even more dependent on chemical causes than on purely thermodynamic ones.

In multi-cylinder engines equal mixture distribution to all cylinders is of paramount importance and preeminently a matter of design. One designer finds success in absolutely straight passages from the carbureter to the valves. Another, strange to say, finds equal success in letting the mixture "ride the walls" of heated volutes. Good physical reasoning, of course, underlies all these designs. In this connection only experimentation and the study of successful arrangements are of serious value. Finally, of course, good carburetion is a prerequisite of power as well as of economy. It is a field where scientific study and reasoning have accomplished much and might accomplish more; a field too vast to be even touched on in this paper.

POWER

The first question to be dealt with is that of the influence of air heating on power. In this connection the way of looking at things which has gained the greatest foothold among practical men is strangely enough one that is apt to be most misleading and least likely to lead to a clear picture of the real happenings in the case. This is the idea that "air-heating reduces weight." One hears frequently: "If you heat the air, you reduce the weight of the charge; hence you cannot get your power." The weight of the charge as such has absolutely nothing to do with either power or economy. The thing that counts is the pressure behind the piston. Take water, weighing a thousand times as much as steam, for example; if the mean pressure exerted during the stroke is the same in the one case as in the other, steam will give as much power as water. At the same temperature and pressure a cubic foot of steam weighs less than an equal volume of air, but expanded in the same ratio, the steam will, if anything, give more power than the air.

To avoid mathematical technicalities as much as possible, it is best to illustrate the influence of air-heating on pressure by two concrete examples. If the mixture at the beginning of the compression stroke has a temperature of 70 deg. fahr., the pressure may be 12 lb. absolute. With the usual compression exponent of 1.3 and a volumetric compression ratio of 4.5, the temperature after compression is 370 deg. fahr. and the pressure 84 lb. absolute. Suppose the combustion to raise the temperature by 2000 deg.; the temperature after combustion is then 2370 deg. fahr. Assuming this temperature rise to take place at sensibly constant volume, the pressure will rise in the ratio of the absolute temperatures, or

$$\frac{(2370+460)}{(370+460)}$$

It will be

$$\frac{2830\times 84}{830} = 286 \text{ lb. absolute}$$

Suppose on the other hand that the mixture at the beginning of compression has a temperature of 220 deg. fahr. At the end of compression the temperature would be 605 deg. Assume again the combustion to raise the temperature 2000 deg., although actually, on account of the increase of the specific heat with the temperature and the increase in the cooling loss, it would take more heat to raise the temperature 2000 deg. from 605 deg. than from 370. With a 2000-deg. increase the temperature in the combustion space would be 2605 deg. The pressure attained would be

$$\frac{3065\times 84}{1065} = 242 \text{ lb. absolute}$$

In other words, heating the mixture 150 deg. lowers the explosion pressure at least 40 lb. The power would go down very much in the same ratio, dropping about 14 per cent.

A few things might counteract this influence:

(1) Air-heating might improve carburetion and distribution
(2) It might render the combustion more rapid and complete

Actually some such effects are traceable in many cases. It is a fact that on the test stand at least even engines running on kerosene show a marked drop in power when the air is heated. In recent tests by the International Harvester Co. this drop was about 10 per cent for maximum power at 900 r.p.m., when the air was heated from 70 to 220 deg. fahr.

DELAYED COMBUSTION

Tests[2] by Messrs. Honoman and McKenzie at the Bureau of Standards with a Liberty engine at 1400 r.p.m. show that even with aviation gasoline the velocity of flame propagation was too low to spread the flame throughout the clearance space in the time interval of one-eighth of a revolution. On the other hand, the flame had time to spread throughout the mixture before the end of the expansion stroke. The conditions were such that the addition of a second spark-plug might have rendered the combustion fairly complete in the clearance space. It is

[1] Professor of machine design, Ohio State University, Columbus, Ohio.
[2] See THE JOURNAL, February, 1920, p. 119.

well known that for large-size engines running at high speed this second spark-plug increases the power considerably. A brief study of the thermodynamical conditions here obtaining and the possible improvements will follow.

To begin with, let us assume the same conditions as in the first mentioned case, a temperature before combustion of 370 deg. fahr. and a temperature rise by combustion in the clearance space of 2000 deg. fahr. Some after-burning will take place, but this can be assumed to balance the cooling loss, so that the expansion proceeds along an adiabatic curve. The expansion exponent under these conditions may be taken as equal to 1.3, the same as for the compression. The volume, temperature and pressure variations throughout the stroke will then be roughly as given in Table 1.

TABLE 1—COMBUSTION IN CLEARANCE SPACE WITH ADIABATIC EXPANSION

Position of Piston, percentage of stroke	Volume Ratio	Temperature, deg. fahr.	Pressure, lb. absolute
0	1.00	2,370	286
10	1.35	2,130	194
20	1.70	1,950	143
30	2.05	1,820	112
40	2.40	1,720	92
50	2.75	1,630	77
60	3.10	1,550	66
70	3.45	1,495	57
80	3.80	1,430	50
90	4.15	1,390	45
100	4.50	1,350	41

The mean pressure is 106 lb. absolute. The compression pressures will be lower than the expansion pressures in the ratio of the absolute temperatures or $\frac{830}{2830} = 29.3$ per cent of the expansion pressures. The mean indicated pressure is hence $0.707 \times 106 = 75$ lb. If the mechanical efficiency of the engine is 85 per cent, the mean effective pressure will be $0.85 \times 75 = 64$ lb. per sq. in.

Suppose the combustion has been delayed in such a manner that the temperature is maintained constant throughout the stroke. To form an idea of the pressure conditions then obtaining let us assume that the mean temperature during the stroke is roughly the same as before,

$$\frac{2370 + 1350}{2} = 1860 \text{ deg. fahr.}$$

We have then isothermal expansion, and the product of pressure and volume throughout the stroke is the same. The actual pressure values are as shown in Table 2.

TABLE 2—ISOTHERMAL EXPANSION AT 1860 DEG. FAHR.

Position of Piston, percentage of stroke	Pressure, lb. absolute
0	235.0
10	174.0
20	138.0
30	114.0
40	98.0
50	85.5
60	76.0
70	68.0
80	62.0
90	56.5
100	52.0

The average pressure would be 105 lb. absolute, or almost exactly the same as before. No change in the mean compression pressure has been assumed. Under the conditions postulated, for the same mean temperature during the stroke, delayed combustion would mean no reduction in power. However, to cover the expansion work at 1860 deg. fahr. about 240 B. t.u. per lb. of gas would be required. On the other hand, to raise the temperature in the clearance space from 1860 to 2370 deg., as assumed in the first case, would require hardly more than 120 B.t.u. If we were working with the theoretical quantity of air, there would be available from the fuel about 1200 B.t.u. per lb. of combustion gas. About 10 per cent of this quantity would then be necessary to cover the extra heat needed in the case of isothermal combustion. With total heat utilization of only 15 to 20 per cent, it will be observed that for any given charge, delayed combustion must mean a very considerable decrease in power.

If instead of a combustion spread over the whole stroke, yet with the pressure peak in the clearance space, we assume that the peak occurs later in the stroke, as is often the case in high-speed engines, a similar reduction in power is arrived at. A rough calculation, for instance, shows that, if this peak of pressure occurs at 20 per cent of the stroke and is followed by adiabatic expansion, with the same heat expenditure as in the first case, the mean effective pressure would drop from 64 to 47 lb., or 26 per cent.

Since over-rich mixtures give a rapid combustion, the temptation is ever present with automotive engines to use mixtures that cannot be completely burned. In tests at the International Harvester Co. the maximum power at 900 r.p.m. with gasoline was obtained with 10 to 11 lb. of air per lb. of fuel, and with kerosene with the same engine and at the same speed with 9 to 10 lb. With kerosene especially this point is very near the limit of possible engine operation toward the end of richness. With mixtures as deficient in air as these, the carbon part of the fuel is very largely burnt not to carbon dioxide, but to carbon monoxide, a great part of the heat value of the fuel being left unused. Any device, whether multiple spark-plugs, means for increasing turbulence, supercharging arrangements, or an entirely different type of engine, which would give a rapid combustion even with lean mixtures containing enough air for complete combustion to dioxide, deserves the most serious consideration and developmental effort.

FUEL ECONOMY

As has already been indicated, a great difficulty in the way of good fuel economy is the circumstance that the conditions for power and economy are largely conflicting. This is, however, a condition that is not peculiar to internal-combustion engines. Similarly in a steam engine a long period of full-pressure steam admission means great power, but a very low expansion; and it is through expansion alone that the full work-doing capacity of the steam, or any elastic working medium, can be realized and hence good economy reached.

This last point does not seem to be as vividly present in the minds of many internal-combustion engine engineers as it deserves to be. In the case of the Otto cycle the expansion and compression ratios are the same. Hence a high compression leads to good fuel economy, but solely because it gives great expansion. In certain more recent engine developments a high compression pressure is obtained by supercharging, and high power is attained by a very great percentage of clearance space. This, however, reduces the expansion and will lead to poor fuel economy, unless, haply, an incident reduction in the friction and cooling losses compensates for the lack of expansion.

That an over-rich mixture will give poor economy on account of incomplete combustion has already been commented upon. It may also tend to reduce economy by virtue of the extremely high temperatures attained in the combustion space and the consequent loss of heat to the jacket. In stationary gas engine practice it has been well known that very lean mixtures with the air much in excess of the quantity theoretically required give better economy than richer mixtures. This has been correctly ascribed to the lower cooling loss with the leaner mixtures. Extremely rapid flame development was not necessary in the case of the slow-speed engines in question. In high-speed engines of automotive type, however, it may be necessary to speed up the combustion, even at the expense of some incompleteness thereof, in order that the heat actually developed may be more fully utilized by succeeding expansion.

From a paper[3] by B. Stockfleth and C. A. Norman, entitled A Tractor Engine Test, are reproduced in Fig. 1 a set of curves showing the influence of the air-to-fuel ratio upon the power developed, and in Fig. 2 a set showing the fuel consumption, both for a tractor engine running on a standard commercial gasoline at 1000 r.p.m. The best fuel economy with air temperatures between 70 and 100 deg. fahr. is obtained with 12 to 14 lb. of air per lb. of fuel, a quantity appreciably less than the 15 lb. necessary for complete combustion. It is only when the combustion is aided by air-heating that the best economy is obtained with leaner mixtures. In all cases, however, a comparison of Figs. 1 and 2 will show that best economy is obtained with mixtures leaner than those which give maximum power.

Air-Heating

A similar situation is found in connection with air-heating which reduces power but may give improved fuel economy. It does so, however, only by making it possible to run on leaner mixtures, thus obtaining better combustion. From actual measurements, given in the paper mentioned, it appears that the jacket-loss percentage as well as exhaust temperature increases with an increased air ratio. This increase is, however, taken out of a margin of unaccounted for, or undeveloped, heat and does not preclude a simultaneous increase of the percentage of useful work.

Theoretically, it is easy enough to prove that the Otto cycle for a perfect gas ought to give an efficiency dependent on the expansion-compression ratio only and not on temperature. Practically too high temperatures will lead to high cooling losses and hence reduce efficiency. Too low temperatures again will give low pressures, large engine dimensions and great friction losses compared with the output. The friction loss in an ordinary automotive engine is only 10 to 20 per cent of the full load output. However, as the engines run mostly at reduced load, this quantity is of not inappreciable influence on the fuel economy. Under extreme conditions, such as those in the Ricardo tank engine, it has been found worth while to adopt extremely "sophisticated" arrangements, like the stepped piston, lubricated by oil fog, to reduce the friction loss. In general, it must be remarked that the present standard automotive engine is criminally wasteful of a type of fuel not easily replaced. Hence the feeling that the present-day engine represents a standard of perfection not to be touched and tampered with is one which is not well founded in either the demands or the possibilities of the situation. In conclusion, just one, not very radical, line of effort at improvement will be dealt with.

[3] See The Journal, February, 1920, p. 99.
[4] See Zeitschrift des Vereiner deutscher Ingenieure, Jan. 25, 1913, p. 135.

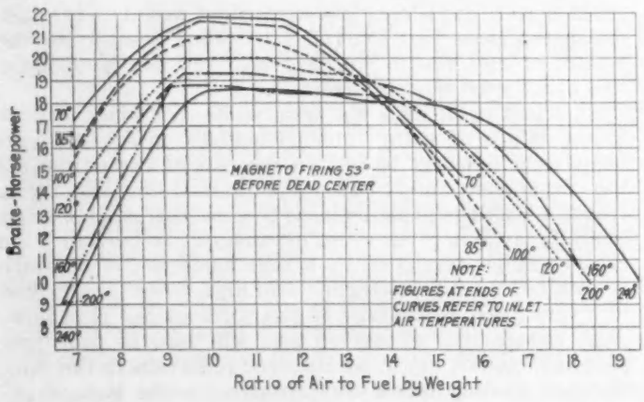


Fig. 1—Influence of the Air-to-Fuel Ratio Upon the Power Developed

Supercharging

Supercharging in general means the introduction of some special means to increase the pressure in the cylinder at the beginning of the compression stroke. It is not improbable that supercharging was first thought of in connection with Diesel engines. These engines are known to have a very "lean" diagram, a very high friction and auxiliary loss and a very great weight per unit of output. To improve this condition, so-called "six-cycle" engines were built experimentally, for example, by Ganz & Co. in Budapest. In these engines every second compression stroke delivered air into a receiver, from which it was drawn back at the end of the succeeding suction stroke, giving a much increased pressure. Such an engine, tested by Schimanek, probably in 1912, gave an increase in power of 20 to 25 per cent over four-cycle operation.[4] Six-cycle operation is not, however, suitable for engines with clearance spaces as large as those of ordinary automotive engines.

One well-known form of automotive supercharging engine uses crankcase compression and admits air at a considerable superpressure through ports at the end of the suction stroke. A considerable increase of power is obtained, but as the inventor accomplishes this not by an increase in the compression and explosion pressures, but by an increased clearance and a reduced expansion, the device as stated does not make for economy, except insofar as reductions in the friction-loss percentage and the cooling loss are secured. Another well-known type of supercharging engine simply admits atmospheric air through a cock at the end of the suction stroke. This arrangement has for its main object the improvement of engine performance at reduced load.

It is the general impression that the automotive type of engine is especially inefficient at reduced load. This is not, however, simply due to throttling governing and to low mechanical efficiency. The Diesel engine has a lower mechanical efficiency than the automotive engine, and its diagram is far "thinner" than that of the latter, making the friction and auxiliary losses count heavily at reduced load. The Diesel engine is, however, governed by reducing the fuel admission, which means in this case reducing temperatures during the expansion stroke, or cooling losses and increasing the expansion ratio. In consequence of these two beneficial factors, the fuel economy of Diesel engines is principally better at three-quarter load than at full load, and the economy curve is very flat generally.

In the automotive engine, on the other hand, the tem-

peratures are not reduced materially by the throttling process, but ignition and combustion are often impaired. One of the main objects of supercharging is to make it possible to run on mixtures leaner than those that can ordinarily be handled and thus cut down the cooling losses. The aim is to keep a rich readily ignitible mixture around the spark-plugs, and as far as possible a cushion of pure air over the piston. Suppose the pressure at the end of the suction stroke to have been reduced by throttling to something like 7 or 8 lb., and that this pressure is increased by air injection almost to atmospheric; with excellent stratification and a barely ignitible mixture around the plugs, this might mean that the temperatures during the expansion stroke would be some 30 per cent lower than without supercharging, and the cooling loss reduced very much in the same proportion. With a useful output of only 15 to 20 per cent of the heating value of the fuel, and a cooling loss of something like 20 per cent, it is obvious that substantial improvements in economy might be realized.

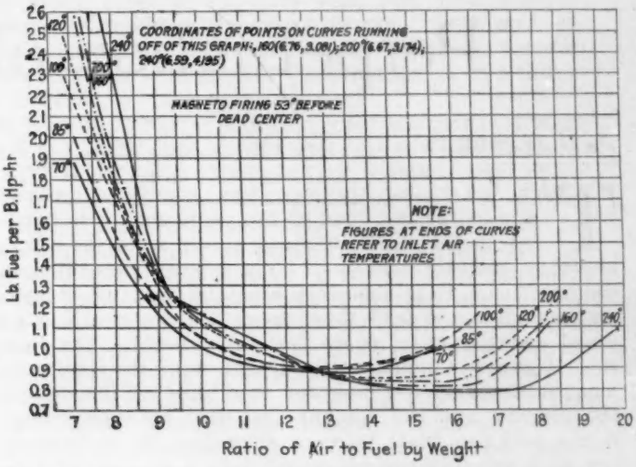

COORDINATES OF POINTS ON CURVES RUNNING OFF OF THIS GRAPH:-,160(6.76,3.08);200°(6.67,3.74),240°(6.59,4.35)
MAGNETO FIRING 53° BEFORE DEAD CENTER
NOTE:-
FIGURES AT ENDS OF CURVES REFER TO INLET AIR TEMPERATURES
Lb Fuel per B.Hp-hr
Ratio of Air to Fuel by Weight

FIG. 2—INFLUENCE OF THE AIR-TO-FUEL RATIO UPON THE FUEL CONSUMPTION

NOTES ON POWER FARMING

(*Concluded from page* 174)

trip, or 0.94 tons per hr., which is equivalent to 22.5 tons per 24 hr. or calendar day. For the 45-hp. units this would be 7.5 tons per calendar day.

By reference to Fig. 1 it will be seen that the total elapsed time available for this operation is seventy-five days. However, all of the tractors are not available for this entire time. They will be in service during the entire harvesting period of fifteen days, leaving but sixty days for hauling.

By further study of the chart and employing the bad weather factor of 78 per cent, it will be seen that the seven 45-hp. tractors after completing seeding operations on Sept. 15, will be able to deliver 1840 tons by Nov. 1. The two 120 or four 60-hp. machines occupied in threshing until Oct. 15 will then be able to go on the road for fifteen days, delivering 525 tons; and the four 120-hp. tractors or the eight 60-hp. outfits released from harvesting on Sept. 1 could begin to haul immediately, and continue for sixty days, delivering in that time 4200 tons; or a total of 6565 tons. The total tonnage to be delivered, based on 12,000 acres and a crop of 25 bu. per acre, would be 9000 tons, so that notwithstanding the excessive amount of rolling stock and motive power provided for above, there will still remain undelivered in the field on Nov. 1, 2435 tons.

NECESSITY FOR NEW TYPES OF ROAD HAULAGE

Thus it develops that in growing wheat in certain regions such as Canada, the Dakotas, Wyoming and Minnesota, where very large tracts are still to be found many miles from the railroad, the number of tractors is primarily determined by the haulage requirements, rather than by agricultural operations. An investigation of tractor road haulage in New York, Illinois and the Dakotas reveals the fact that only 15 per cent of the owners do hauling with tractors and that only 4 per cent of a tractor's yearly work is devoted to such service. This is undoubtedly due, as has been pointed out herein, to the extremely unsatisfactory and expensive nature of such service with unsprung tractors and crude wagons.

Some years ago there was developed by a Connecticut manufacturer a road train with a gas-electric generating station on wheels at the head of the train. This powerplant, and also each trailer, of which there could be a large number, were driven by electric motors, fed from and controlled by this powerplant. All the wheeled units were spring-mounted and rubber-tired and could handle large loads at high speed. If the present demoralization of our railroads continues, such expensive equipment may be the next step in road transportation.

CONCLUSION

I have described a one-year cycle of events in one particular branch of farming, and outlined the degree to which the engineer is vitally interested therein and responsible therefor. All other lines of agriculture, from fruit to cotton and cane, await in even greater degree improvement in methods and apparatus at the hands of the engineer.

As our soils become exhausted, deeper and more perfect cultivation must be resorted to, crops once raised must be harvested with less loss and fewer men, and the old kinds of tractors and fuels, plows and harrows, drills and packers will no longer be satisfactory. New and better built machines must be invented and used to take the place of the human being who, as the result of chaos throughout the world, is daily abandoning the farm for a larger share of the shorter hours, easier work and pleasanter ways of living among the ranks of the non-producing city dweller.

Perpetuation of Our Highways

By H. G. Shirley[1] (*Non-Member*) Semi-Annual Meeting Address

THE life of our highways has become so problematic in the last four or five years that it is creating in the minds of many a fear as to the advisability of the continuation of large expenditures for road construction. It is therefore essential that we investigate and find out why these roads are not standing up under today's traffic as we feel they should. The Federal Highway Council realized that with the enormous amount of money available for road building throughout the country and the amount that will be appropriated in the next few years to come, as well as the prospect of the national Government going into road construction on a larger scale than heretofore, it is absolutely necessary that a thorough study and investigation be made of the entire road-building situation to the end that this large fund shall be expended in the most efficient manner and produce roads that will give the greatest service and have long life.

The investigation as to why failures occur in our roads naturally leads to their constructional features. It became evident that 80 to 90 per cent of such failures were due to something other than the surface crust, namely the sub-base foundation. This led to some preliminary studies as to the character of the sub-base and what could be done to stabilize and make it such that these failures would not occur. Before the advent of the motor vehicle, during the spring thaws the roads would be loosened up and torn to pieces by frost, but the traffic was not heavy enough at that period of the year to destroy the crust that had been affected by frost and moisture. After this layer had dried out, under light traffic, it would gradually consolidate again and become capable of carrying the traffic another season. This went on year after year, until earth had permeated the surfacing to such an extent that the surface crust finally failed and terminated in a mud-hole. Since the advent of the motor vehicle the surfacing is broken to pieces under the heavy load, the wheels of the vehicle crushing into and often breaking through it, thereby destroying the surface crust, and requiring its replacement or renewal. This action has in the past few years during the spring thaw caused the roads to go to pieces, necessitating their being restored at very heavy expense. It is irritating to the public to see costly roads destroyed annually by heavy traffic and they cannot understand why this is the case. If it were possible to keep the sub-base dry, the crust could, I believe, be made very much thinner, the destructive effect of the freezing on the surface crust would be eliminated and the crust would be capable of carrying a maximum load at all seasons of the year.

Road Failures Due to Clay Sub-Base

In investigating the road from Washington to New York, the portion which lies in the state of Maryland, having been constructed under my supervision, gave me a peculiar knowledge of its construction as well as its sub-base. The failures were almost universally due to a clay sub-base or soils that have a large percentage of clay. The drainage system installed in many places ceased to operate, due to the clay becoming fluid during the thawing period, running into the underdrain pipes and completely clogging them. This clay would dry during the next summer, making a permanent stoppage of the entire system. We therefore realized that many of the most improved and advanced ideas in drainage such as the tile drain, the French drain and others proved absolutely inefficient in certain soils. It was obvious that some serious investigation should be made of the different soils under our road surfacing to determine a method by which they can be treated so as to make them more stable. In doing the latter it is necessary to eliminate all moisture due to seepage or capillary action.

When investigating some of the clays over which failures occurred, the Bureau of Public Roads extracted from these a liquid having a reddish-orange color and containing no sediment after standing a long period. Under an ultramicroscope, of the very highest power owned by the Government, this liquid showed that it contained a large quantity of particles of mica in solution. These were so minute that they could be detected only with the high-power microscope.

This liquid has waterproofing properties. When it is treated with lime, a precipitation is immediately brought about, the liquid being cleared up and a sediment deposited on the bottom of the glass resembling burnt clay and having similar characteristics. This suggested the possibility of a treatment of the sub-base with lime or cement, not with the idea of binding the particles together but of neutralizing the gluey substance in the clay and turning it into a non-plastic soil that would not hold moisture or have the power by capillary action of drawing and holding moisture. The Bureau of Public Roads is now working on the precipitate to ascertain whether it will remain in this condition, and under frost action not return to its former state of plasticity and resume the characteristics it had before being treated. The indications are that when so treated it will not return to its original condition. It may be possible to treat the sub-base and improve its bearing power to a very great extent. Other experiments are being conducted with the idea of subjecting the sub-base by a treatment of light oil to supersaturation, so that we can have an impregnated cushion under the surface that will not take up moisture and be affected by freezing and thawing.

It is possible to have waterproof curtain walls on each side of the road under the surfacing, carrying them down to such a depth that they will prevent water getting under the surfacing and softening the sub-base. If some treatment can be found that will render the sub-base more stable, and the different soils can be classified so as to determine their bearing power after treatment, a great step will have been made in road-building in this country.

Local Soil Conditions Must Be Considered

We are today building roads from East to West under what may be termed standard specifications. A contract will be let for building a road 8 in. in the center and 6 in. on the sides, this thickness being used over the entire length of the road, regardless of the varying

[1]Secretary, Federal Highway Council, Washington.

condition of the sub-base over which it is laid. On the sands of Delaware, over the gumbo of Illinois and the shale cliffs of Colorado and Wyoming, the same thickness is being used. The sands of Delaware have almost perfect drainage, and it is only necessary to determine their bearing capacity to know the thickness of slab that should be used to carry a given load. They are not affected to any great extent by frost and therefore make a good sub-base, although they do not give the very highest bearing resistance. The gumbo of Illinois and the clay soils of Ohio become practically semi-fluid in the spring. The road surfacing having been greatly weakened and cracked by freezing action in many places, renders it incapable of carrying the load over this semi-fluid base. The thickness of road used on the sands of Delaware is absolutely inadequate in Ohio and Illinois. In Colorado and Wyoming where the shale cliffs themselves make very good roads, we find the same thickness used, it being known that the sub-base is little affected by frost on account of the shales being impregnated with oil and being a hard substance affected only slightly by water, and giving maximum bearing resistance. A slab of 8 in. in the center of the road and 6 in. on the sides will give a very much greater strength than is necessary for the same loading as that in Delaware and Illinois.

We therefore see that the surface of the highways is not being constructed to give a road of uniform strength throughout the country. In other words, we have a chain of highways the surfacing of which at some points is too weak, while at others it is unnecessarily thick, to carry the maximum uniform load. A chain of roads with many weak links! The conditions and types of soil are so diversified that we may find a sandy soil in one place, and just a little distance beyond a loamy stretch, then clay, another loamy section and so on. If a successful job is to be had, a thorough study must be made of local soil conditions. A profile will have to be made of the soils and the road designed to meet the varied conditions, or the sub-base brought to a known condition by special treatment.

The object of this whole study is to pursue and assist in the investigation being made by the Bureau of Public Roads to the point where a few simple tests can be specified and made by the inspector in the field and he will be able to determine just what treatment should be given the sub-base and the section to be used to carry a given load. Much research and study has been carried on and a great amount of money has been spent in bringing together and placing the surfacing materials for highway construction. We have arrived at a point where these materials are fairly well understood and can be handled in a very satisfactory manner. We know their physical and chemical characteristics and their action under traffic, and it is with this in mind that we hope to arrive at a solution of the sub-base problem so that an inspector can direct the building of a road over every type of sub-base that will have uniform strength throughout its entire length. This may require a treatment of the sub-base by chemicals, removal of the sub-base entirely and the substitution of a different material, or improved drainage.

If we wish to have highways that are going to withstand the traffic passing over them the problem indicated must be solved in an intelligent and practical way; otherwise it would be inadvisable to expend the large amount of money that will be necessary to provide properly for the traffic that is carried on and that will come upon the highways in the near future. It would not be expedient for the United States Government to construct a system of national highways before this problem has been solved to such an extent as to make it certain that the money would bring in a proper return. I, therefore, want to impress upon your minds the great importance of this study. It will mean millions of dollars saved annually, it will encourage the public to appropriate larger sums of money for road construction and all can look forward with assurance that the program which is necessary to put highway transportation on an efficient basis will be carried on successfully and in the least possible time.

A Suggested Road-Building Program

To give briefly an idea of what in my judgment is necessary to be accomplished in road building to take care of the present traffic needs, I would say that the United States Government should build not less than 30,000 miles of national highways, the State highway departments not less than 150,000 miles of improved highways, and the counties not less than 200,000 miles of improved roads; making a total of 380,000 miles of highways to be built. Adding to this approximately the 200,000 miles of improved roads that we already have makes nearly 600,000 miles of improved highways, which in my judgment is necessary to develop the country and take care of its traffic needs in the next ten years. This would leave 1,900,000 miles of unimproved roads to be looked after by the counties.

I want to call attention to another thing which I hope you will give the deepest thought. We have not as many miles of improved roads today of a character and strength to take care of the traffic that passes over them as we had in 1900 to serve the traffic of that day. There will probably be constructed in this country this year from 2500 to 3000 miles. We should have about 40,000 miles constructed annually in the next ten years. We hear a great many people say, "Great progress is being made in road construction in this country." Great progress is being made in the way of providing the money and in the methods of road construction, but we are falling backward at a rapid rate in the number of miles being constructed in comparison with the number that should be constructed.

DESTINY OF AUTOMOBILE BUSINESS

IN a general way no one will question the destiny of the automobile business. I hardly believe that even the most conservative banker would call the automobile of today a luxury or an unessential if he gave it a little thought. You hear many thoughtless remarks and statements, but they can not survive the light of facts. The same things were said of the telephone, the railroad and other epoch-making revolutions in modes of life.

To any one who lived east of the Mississippi in the days of the war when the gasless Sundays were in vogue, no words are needed to portray the essentiality of the motor car, and if one can picture a gasless Monday or Tuesday, one can imagine what it would mean to our social structure. How would the people get to business? How would wares be delivered? Can any one question the essentiality of this mode of transportation? The other transportation systems of America could not begin to handle the loads.—F. E. Moskovics.

Saving Fuel with the Carbureter

By W. E. Lay[1] (*Member*)

Semi-Annual Meeting Paper *Illustrated with* Charts

In the effort to conserve the internal-combustion engine fuel supply during the war an article was published in which the statement was made that 270,000 gal. of gasoline was burned unnecessarily every day through leaky and badly adjusted carbureters. There are grave doubts if the quantity mentioned is nearly large enough to cover the quantity of fuel which might be saved by care in the adjustment and operation of the average carbureter.

Mixture-Ratio Tests at University of Michigan

In the spring of 1918 some investigations were made at the University of Michigan into the effect of varying mixture ratios on the thermal efficiency and torque of an engine operating under different conditions of speed, power output and temperature of the fuel-intake system. The tests made may be conveniently divided into two series.

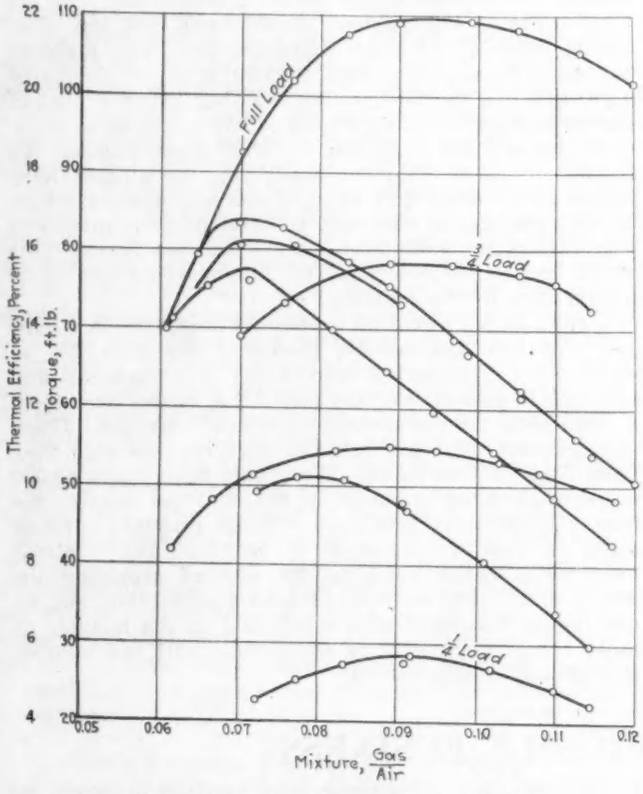


Fig. 1—Result of First Series of Tests

The object of the first series was to determine whether the mixture giving the best economy and that giving the greatest power is a constant quantity for all conditions of speed and power output of the engine such as quarter, half, three-quarter and full load.

The object of the second series was to determine what effect any changes in the temperature of the fuel-intake system have on the quality of the mixture which gives the maximum power and that giving the best economy.

The tests were conducted on the four-cylinder engine used in the standard Government ambulance. The fuel system on this engine includes a carbureter using a primary air passage, a primary fuel-jet, an auxiliary air passage with an air-valve and a secondary fuel-jet. A curved riser conducts the fuel mixture from the carbureter outlet to the manifold proper which is cast integrally with the cylinder-block.

The fuel consumption was measured by sensitive balances which controlled electrically a stop-watch and a revolution-counter. The air used by the engine was measured by a venturi meter and maintained at any desired temperature by an electric heater. The power output of the engine was measured by an electric dynamometer.

By trial the needle-valve of the primary fuel-jet was adjusted to the position which gave the maximum power at the desired speed and power output. The throttle and the spark were then fixed and the operating conditions of the engine maintained steady and constant while the fuel-consumption and torque determinations were made with various needle-valve positions. These needle-valve positions ranged from that which gave a mixture so lean that the engine would barely operate without missing to that giving a mixture rich enough to produce a galloping action of the engine.

The results of the first series were plotted on curve sheets (See Fig. 1) using the ratio by weight of gasoline to air in the mixture as abscissas and torque and thermal efficiency as ordinates. A study of the curve sheets brings out the following points:

(1) The mixture quality giving the greatest power is very different from that giving the best economy. The engine uses approximately 25 per cent more gasoline per brake-horsepower-hour when running on the quality of mixture giving the greatest power output than on the most economical mixture

(2) The mixture giving the maximum economy becomes somewhat leaner as the power output is increased

The results of the second series which were plotted in a similar manner (See Fig. 2) were obtained by changes of the temperature of the air entering the carbureter instead of the engine output. From these results the following conclusions can be drawn:

(1) Over the temperature range investigated an increase in the carbureter-intake temperature means an increase in the thermal efficiency

(2) The mixture giving the best economy at a high temperature is a leaner mixture than that giving the best economy at a lower temperature

[1]Assistant professor of mechanical engineering in charge of automotive engineering, University of Michigan, Ann Arbor, Mich.

Various Carbureter Operating Conditions

In the operation of a carbureter there are conditions under which economy is sometimes desired without need of increase in power, and sometimes power is the prime requirement without regard to economy. Under conditions of touring at a reasonable speed, where there is continued operation of the engine under fairly constant conditions, the prime requisite is economy in the use of fuel. Here the carbureter should supply the lean mixture, which will give the maximum economy with the engine well warmed up and the intake-manifold temperature high. However, should the car be climbing a steep hill, or going through deep sand with the throttle wide open, it might be advisable to supply the engine with the richer mixture giving the greater power. This may also be true when the car is traveling at its maximum speed.

There is another condition of carbureter operation, occurring when the throttle is suddenly opened to accelerate the car, that presents an even greater difficulty. In this case it ought to suffice to furnish the engine with a mixture that will develop the maximum power during the period of acceleration, but that is not enough. At the low speed before acceleration the throttle is nearly closed, and the high vacuum in the intake manifold is separated from the carbureter, resulting in comparatively low velocities of both fuel and air through their respective orifices or passages in the carbureter. When the throttle is suddenly opened an entirely different condition results. The moving streams of air and fuel are both subjected to the greatly increased pull of the greater vacuum. The airstream, because it is light, speeds up very quickly, while the velocity of the gasoline, with its greater inertia, is only slowly increased to meet the new conditions. Hence for a moment the engine receives a very lean mixture. It may be so weak, in fact, that it will not explode and may continue over a period so long that the engine will stop entirely.

Thus, though the carbureter will operate perfectly with the throttle nearly closed or if it is gradually shifted to the new wide-open position, it will not operate satisfactorily after a quick change. It is obvious that the operation during acceleration can be remedied in two ways: by holding back the air or by pumping in more gasoline momentarily until the carbureter has adjusted itself to the new conditions.

Maximum Power
Requiring a richer mixture
Cold engine
Hill climbing, high speed, acceleration
Throttle wide-open
Maximum Economy
Requiring a lean mixture
Continued ordinary operation with engine well warmed up

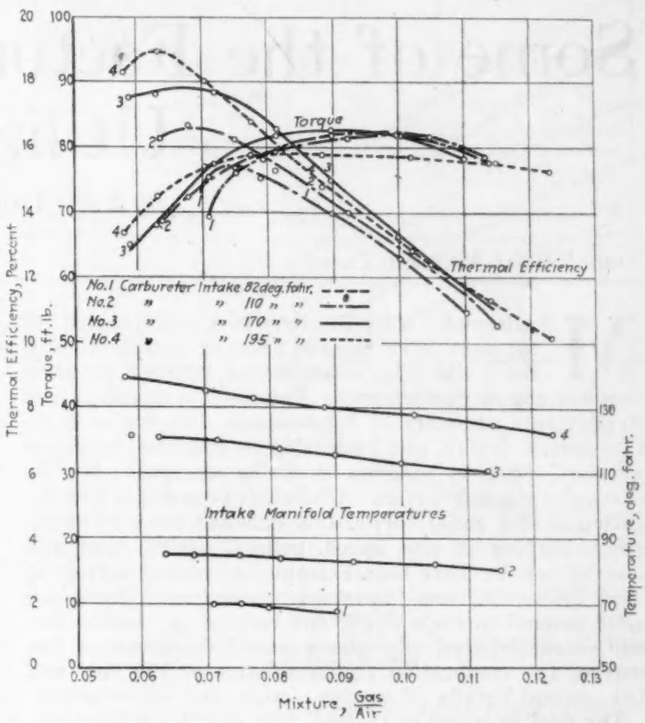


Fig. 2—Results of Second Series of Tests

The conditions under which a carbureter is obliged to operate can then be summarized as given at the bottom of the preceding column.

The Ideal Carbureter

The ideal carbureter would be arranged so as to supply primarily the mixture giving the best efficiency and automatically supply the necessary additional fuel only when operating conditions require it. The provisions made should be so adequate that the economy under proper operating conditions will never be sacrificed to obtain more power or better operation under exceptional conditions. If no provision is made to meet the various requirements automatically, a manually controlled adjustment, with which a skilful operator may obtain excellent results, is generally supplied. The average driver is not skilled and does not care to change an adjustment constantly. In fact, when he has once made a carbureter adjustment rich enough to give good engine operation with a cold engine on acceleration, and hill-climbing without actually causing his engine to "gallop" under ordinary conditions, he much prefers to leave it strictly alone. The result is that he may use anywhere from 10 to 50 per cent more gasoline than is really necessary.

THE THEORY OF THE ACCELEROMETER

E. P. WARNER, chief physicist of the National Advisory Committee for Aeronautics, has prepared some notes on the theory of the accelerometer which have been published by the Committee as Technical Note No. 3. The accelerometers which have been developed for use on airplanes are of two types, one in which a semi-circular glass fiber is used as the deflecting member and the other which is the one developed by the staff of the National Advisory Committee where a flat steel spring is employed. After a brief description of the second class of accelerometer the obvious apparent errors and means for reducing them to a minimum are discussed. The equations of motion are then given and from these the lag in responding to shocks, the damping of the sensitive member and the possible errors due to resonance with vibrations of the engine are taken up. From an analysis of these equations and comparative laboratory tests the conclusion is drawn that the second type of accelerometer is theoretically, at least, very accurate. A copy of this pamphlet can be obtained from the National Advisory Committee for Aeronautics, Washington.

Some of the Factors Involved in Fuel Utilization

By P. S. TICE[1] (*Member*)

SEMI-ANNUAL MEETING PAPER *Illustrated with* CHARTS

MY laboratory activities have been concentrated for the past seven months upon an examination of the controlling relationships between carburetion and engine performance. This work was undertaken to provide a summary of fundamental data for carburetion system design, and to develop an effective short program of work to be done in fitting an engine for its particular class of service. While this program of investigation is still going forward, a sufficient number of engines, varying in size, speed, general design, type and class of service, have been examined to permit arrival at some interesting and important conclusions. These are quite general in their scope, and involve (*a*) fuel-metering characteristics, (*b*) the physical structure of the charge, (*c*) combustion characteristics of the fuel and (*d*) several details of engine design and manufacture.

The first item can be treated very briefly for the present purpose, since, as between typical engines with respect to size and speed range, the variation in requirements is small. In every throttle-controlled engine the variation in fuel metering for optimum utilization is inversely functional with the relative loading and with the compression ratio. The nature of the fuel leaves these general relationships undisturbed. On the other hand, the physical structure of the charge, by which is meant both the degree of distribution of the fuel content and the state in which it exists, is of great importance, since upon this factor depend largely the net performance of the engine, and also, to some extent, the order of variation of the optimum metering with any change in load. It will be granted that perfect homogeneity in the charge is theoretically the desired condition, but it was early found in a progression toward this result that it cannot be attained without inducing losses in performance. In order that each minute space occupied by the charge may contain the same proportions of air and fuel as every other like space, which is the condition of perfect homogeneity, it is obvious that the fuel must exist in the vapor rather than the liquid state, and that admixture must have been carefully attended to in forming the charge. But the condition that the whole of the fuel be present as vapor presupposes that the temperature of the charge be high enough to maintain it in this state.

EFFECT OF CHARGE STRUCTURE ON ENGINE PERFORMANCE

Since the output of an engine is limited solely by the amount of heat made available in it in unit time, which in turn is directly as the relative oxygen content of the charge, with any one fuel, it is seen that as structural perfection in the entering charge is approached the possible useful output of the engine is reduced. Starting with the least perfectly formed entering charge that will operate an engine, increased outputs result from a more nearly uniform distribution of fuel in the charge, even though this last is accompanied by a reduction in charge weight. It is true also that materially reduced specific fuel consumptions result from further equalization of the fuel distribution in the charge to a point where much less than maximum possible output is obtainable. It is equally true that when the goal of minimum specific fuel consumption is attained in practice the charge is far from being a truly homogeneous one, as it passes the intake valves. The distribution of fuel in the air of the charge under this condition is relatively very good, but the major part of it *must* exist as liquid; and anything done to augment the vapor content at this point brings about a net loss in performance. What happens in the charge structure within the cylinder during the aspiration and compression strokes is in some respects an open question. It is hoped that certain much-needed direct experimental evidence will be available shortly in this matter.

The outstanding charactertistic differences among our fuels are their relative volatilities and their behaviors at and during combustion. Unfortunately, one cannot consider these items separately under service conditions. The less volatile the fuel the more extensive the initial preparation that must be devoted to it before entry to the cylinders, to insure that it be most usefully distributed, and this most useful charge structure is attained only through means which raise the charge temperature. Experimental evidence shows that to have the same charge structure with two fuels, the temperatures in the two cases will stand somewhat as the total heats of vaporization of the fuels.

Considering available petroleum fuels, those requiring the higher charge temperatures for maximum utilization also possess the ability to ignite at relatively lower temperatures, when worked up into mixtures suitable for engine use. It is no difficult thing to visualize what happens when fuels are substituted in an engine. A fixed compression ratio will result in higher terminal compression temperatures, the higher the initial charge temperature. At the same time, the charge having the higher initial temperature is often inflammable at a lower temperature than is the other. The result in such a case must be at least a nearer approach to autoignition upon compression of the higher temperature charge.

In Fig. 1 are curves of terminal compression temperature against compression ratio for several initial charge temperatures. If the act of compression alone were responsible for heating of the charge, it would be possible to use ratios resulting in a close approach to the temperature indicated as that of autoignition, but, because of such other sources of heating, we are limited to compression ratios which in themselves would not take the charge temperature beyond that value indicated by the line marked "usable compression ratios." Experience shows that there is incipient autoignition along this lat-

[1]Engineer in charge of carbureter division, Stewart-Warner Speedometer Corporation, Chicago.

ter line, proving that autoignition temperatures are attained. Hence this graph may be taken as approximately expressing the reduction in the compression ratio, and therefore in performance, imposed by our present imperfect temperature distribution in the combustion-chamber walls, and by the initial charge temperatures imposed by the nature of our fuels.

If autoignition does occur before passage of the spark, it is a case of preignition, but if the autoignition temperature is not attained before the passage of the spark, one of two things results. Either the combustion is sufficiently near normal rate to be usable, or the ignition by spark and the resulting pressure wave through the charge cause the temperature of the major portion to rise to that of autoignition. When this happens, nearly the whole charge burns at once, giving detonation, the evidences of which are violent knocking, loss of power, sooty exhaust and a reduced exhaust temperature.

What data we have show that it should be possible to operate an engine continuously at open throttle, without detonation, on a properly constructed charge of any petroleum fuel proposed to date, with a compression ratio resulting in gage pressures up to and including 75 lb. per sq. in. Actually, we are not able to do this as yet, in service. The analysis of our failure does not proceed very far before it becomes evident that the detonation or preignition experienced is the direct result of local overheating in the charge. Everyone is familiar with cases where a great improvement has been effected by augmenting the turbulence. Now, the important effect of increased turbulence in a charge having an initially suitable structure is to equalize the temperature distribution in it. It is very likely that greater turbulence results in a higher mean temperature in the charge, rather than a lower one, but no one will gainsay its advantages in such a case.

Conditions in the Cylinder

This brings us to a consideration of the conditions surrounding the charge in a cylinder. If turbulence prevents local overheating, it must be that appreciable inequalities of wall temperature exist. This is evidently the case. There are the piston, the exhaust valve and the plug electrodes, as representing combustion chamber surfaces that are not in direct contact with an external cooling or temperature equalizing medium. As yet it is impossible to state with complete accuracy with which of these hotter surfaces the greater responsibility rests. However, this much is certain; high piston-head and exhaust-valve temperatures contribute much to the condition of detonation, while very rarely if ever causing preignition; and preignition is almost always initiated at the spark-plug electrodes.

Piston design is a subject that has had much attention, but from our present point of view, this attention has not until recently been most usefully directed. It is safe to say that the most advanced thought in piston design, which treats it as a thermal rather than a mechanical member, has hardly reached those who can make the best use of it. For a brief statement of some of the very much worth-while things the piston can be made to accomplish, one cannot do better than read the paper[2] by Dr. A. H. Gibson, on air-cooled cylinders.

The exhaust valve, it seems, is an old offender. Beyond question, this is the most grossly overheated part in the engine and requires very effective treatment of design and environment if active trouble is to be avoided. Of the two parts by which heat can be removed from the

[2]See *Automotive Industries*, May 20, 1920, p. 1156.

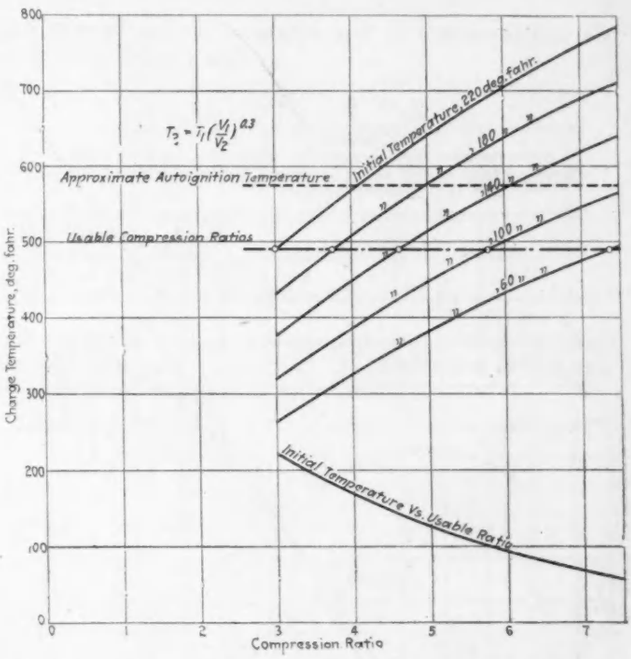


Fig. 1—Curves of Terminal Compression Temperature and Compression Ratios

valve-head, the seat can conveniently be made most useful. At the same time, the path afforded by the stem must not be overlooked, since it is always an open one. Housing of valve-stems and springs is not conducive to cooler valve-heads. Piston-head surface is relatively large, and exhaust-valve-head surface relatively small, but the former is much cooler. The piston-head can be responsible for a considerable rise in temperature of a large mass of charge, while the exhaust-valve head may account for an excessive rise in a comparatively small mass. Both these surfaces emit much heat by radiation, as well as by convection and conduction.

With the higher initial charge temperatures employed with the heavier grades of fuel, all working faces of the combustion space acquire higher temperatures, and therefore require that some advance be made in their cooling provisions. While it is unthinkable that internal cooling can be employed to control the piston and exhaust-valve temperatures, the evidence all points to that means as most suitable in the case of the spark-plug electrodes. If the electrode masses are made as small as possible consistent with complete failure to fuse at full load, and they are given relatively large surfaces freely exposed in the main combustion space, the flow of the fresh charge about them can ordinarily be depended upon to keep their temperatures sufficiently low.

Before leaving engine design details, it is desired to mention briefly one other phase of piston design, its gas-tightness. Not only does piston leakage reduce output and thereby increase the specific consumption of fuel, but it is responsible for dilution of the lubricating oil. Appreciable dilutions occur, we know, with even the most volatile fuels. Several possible remedies can be employed, and probably one of the best of these is to draw the carbureter air through the crankcase, thereby reducing the partial pressures of the vapors in that space to values well below those of saturation. Much of the diluent will then evaporate and be removed with the air. If the case is kept hot enough, with this method, average dilution can be made almost negligible. The real

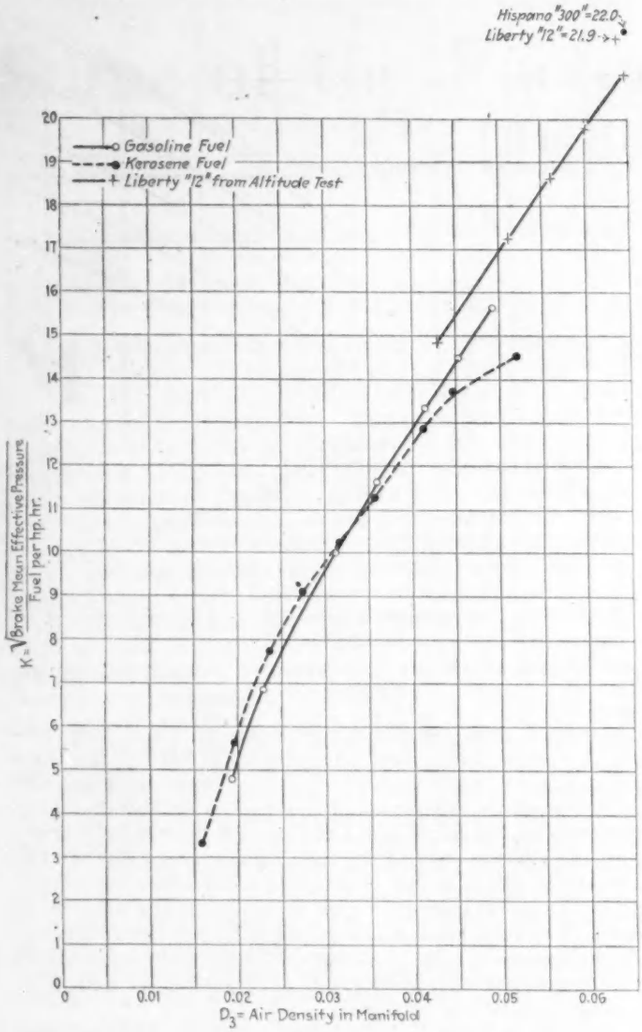

Hispano "300"=22.0
Liberty "12"=21.9
Gasoline Fuel
Kerosene Fuel
Liberty "12" from Altitude Test
K = √Brake Mean Effective Pressure / Fuel per hp. hr.
D3 = Air Density in Manifold

FIG. 2—COMPARISON OF A TRACTOR ENGINE USING GASOLINE AND KEROSENE FUEL WITH A LIBERTY AIRCRAFT ENGINE

stumbling block here is that the air-cleaners of today are not to be trusted to this extent. But after considering everything, we can hardly fail to conclude that the best treatment is prevention rather than cure. The oil diluent is getting past the pistons.

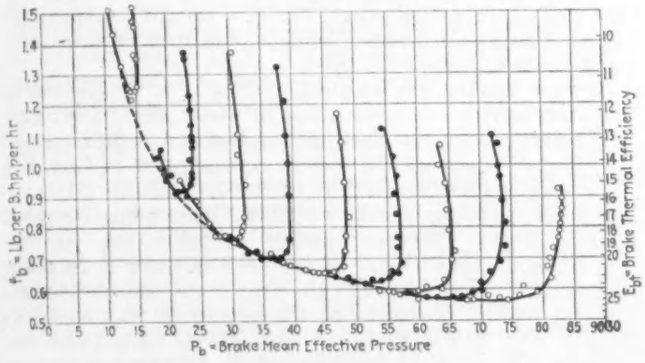


FIG. 3—EFFECT OF CHANGING THE COMPRESSION RATIO AND REDESIGNING AND RELOCATING THE SPARK-PLUG ELECTRODES IN A KEROSENE-BURNING TRACTOR ENGINE

CRITERION OF ENGINE PERFORMANCE

At this time there is no generally accepted working definition of fuel utilization, or of engine performance in its relation to utilization. In most minds utilization has meant merely the inverse of consumption; while performance is synonymous with power. It seems that when we say "fuel utilization" we mean primarily the cost of power, rather than the fuel cost of operation. Likewise, by the expression "engine performance" we must mean the relation between the power obtained and the fuel outlay. Viewed in this way, the one is correlative to the other.

In the foregoing the term "net performance" has been used, the purpose being to embrace in a single expression the two ideas, the cost of unit power and the amount of power obtained. It seems that the first is best expressed

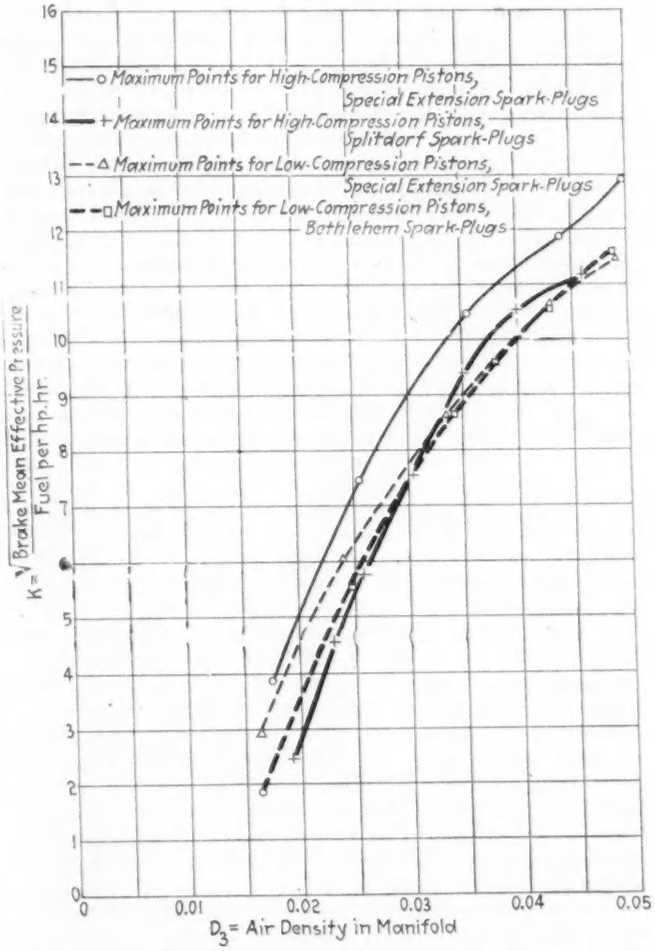

Maximum Points for High-Compression Pistons, Special Extension Spark-Plugs
Maximum Points for High-Compression Pistons, Splitdorf Spark-Plugs
Maximum Points for Low-Compression Pistons, Special Extension Spark-Plugs
Maximum Points for Low-Compression Pistons, Bethlehem Spark-Plugs
K = √Brake Mean Effective Pressure / Fuel per hp. hr.
D3 = Air Density in Manifold

FIG. 4—TEST RESULTS UPON WHICH THE CRITERION VALUES GIVEN ARE BASED

by the brake specific consumption and the second in terms of the brake mean effective pressure. Consideration given this matter indicates that a useful criterion of "net engine performance" is established in the quotient resulting from the division of the square root of the brake mean effective pressure by the brake specific consumption. The use of this quantity as a criterion of performance expresses an easily workable and just relationship between cost and value received, without exaggerating the importance of either item. That it is not a wholly illogical expression is seen when it is written in

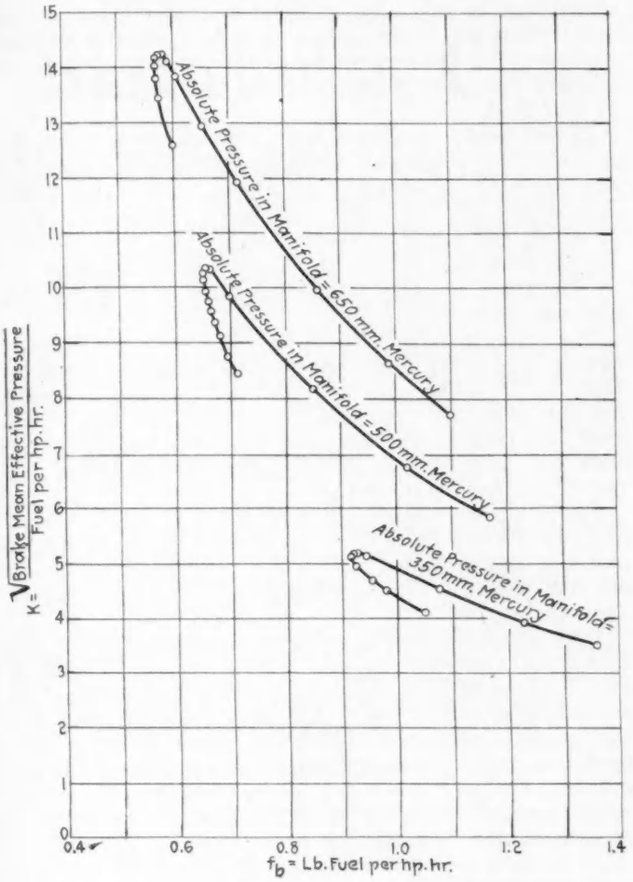

Absolute Pressure in Manifold = 650 mm. Mercury
Absolute Pressure in Manifold = 500 mm. Mercury
Absolute Pressure in Manifold = 350 mm. Mercury
K = √Brake Mean Effective Pressure / Fuel per hp. hr.
f_b = Lb. Fuel per hp. hr.

FIG. 5.—CURVES OF CRITERION VALUES PLOTTED AGAINST BRAKE SPECIFIC FUEL CONSUMPTION

terms of the engine constants and of the quantities directly observed in a test.

$$\text{Criterion} = \frac{\sqrt{P}}{f} \times \frac{NQ^{1.5}}{F\sqrt{La}}, \text{ where}$$

P = Brake mean effective pressure
f = Fuel consumption in pounds per brake horsepower per hour
N = Engine speed in revolutions per minute
Q = Torque
F = Fuel consumed in a unit time
L = Length of stroke in feet
a = Area of piston in square inches

For a given engine it is proportional to $NQ^{1.5}/F$; and for a given speed is simply $Q^{1.5}/F$. The value of this criterion, under best general conditions of engine design and carburetion, attains its maximum with mixtures only slightly richer than those resulting in the true minimum specific consumption. It shows in good perspective the results of carburetion, compression ratio or other modifications in an engine, it permits of a truthful interpretation of part-throttle operation in terms of that at open throttle and affords a means of comparing directly the performances of engines, regardless of type of design or service. A very good tractor engine, operating on kerosene, can have an open-throttle performance rating under this criterion of from 13.5 to 14.0; while the same engine on gasoline can rate at from 14.0 to 14.5. The accepted type of higher-speed car engine will very rarely exceed 15.5, and highly developed aeronautic engines rate at between 21 and 24 at their best speeds.

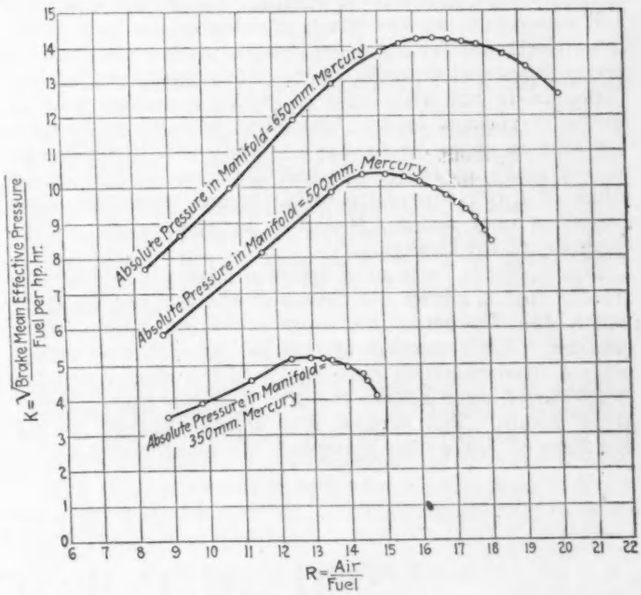

Absolute Pressure in Manifold = 650 mm. Mercury
Absolute Pressure in Manifold = 500 mm. Mercury
Absolute Pressure in Manifold = 350 mm. Mercury
K = √Brake Mean Effective Pressure / Fuel per hp. hr.
R = Air / Fuel

FIG. 7—RELATION BETWEEN CRITERION VALUES AND THE MIXTURE RATIO

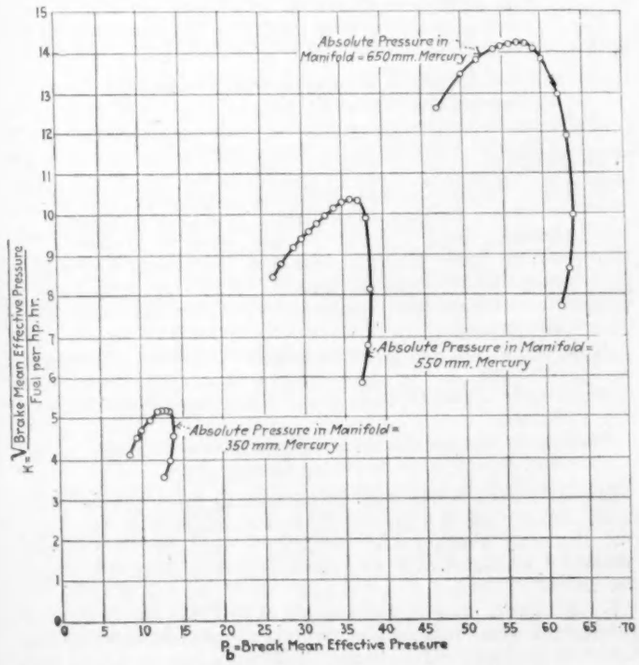

Absolute Pressure in Manifold = 650 mm. Mercury
Absolute Pressure in Manifold = 550 mm. Mercury
Absolute Pressure in Manifold = 350 mm. Mercury
K = √Brake Mean Effective Pressure / Fuel per hp. hr.
P_b = Break Mean Effective Pressure

FIG. 6—CURVES OF CRITERION VALUES AND BRAKE MEAN EFFECTIVE PRESSURES

In the curves of Fig. 2 is a direct comparison of a highly developed tractor engine, operating on both gasoline and kerosene, with the Liberty-twelve aviation engine. In the case of the former the effect of incipient detonation with kerosene fuel is well shown by the abrupt change in slope between the densities of 0.045 and 0.052. Points for the Liberty twelve are taken from published data in altitude performance tests, the criterion values at the smallest densities being omitted because of the self-evidently too rich mixtures used.

The failure of the tractor engine curve to join up with

that for the Liberty engine may be accounted for by the higher mechanical efficiency of the latter, and also to some extent by possible errors in the density values assigned to the Liberty points. Judging from the close agreement in momentary slopes and the straightness of the curves for gasoline in these two engines, it may be taken that the net performance as expressed by this criterion is directly as the air density of the charge, at densities greater than half that of the standard atmosphere. This points to the importance of securing high volumetric efficiency and of maintaining the lowest permissible charge temperature.

Fig. 3 shows kerosene performance in another tractor engine and directly compares the effects of compression-ratio change and of the redesign and relocation of the spark-plug electrodes. A comparison of the triangles and squares shows the effect of substituting long, small mass electrodes for short heavy ones, with a compression pressure somewhat under 70 lb. gage. Open-throttle performance is but little affected, while a marked gain is shown at reduced loads. The effect of raising the compression to about 75 lb. gage is shown, with these two sets of plugs, by the circles and the crosses. The direct effect of this compression-ratio change, using the more favorable plug design, is shown by comparison of the circles with the triangles.

Fig. 4, from tests of a four-cylinder 4½ by 5½-in. tractor engine shows the nature of the test results from which the foregoing maximum criterion values were obtained. Each member of this family of curves represents a fixed manifold pressure, with the charge proportions varied over nearly the whole of the steady operating range. The broken line drawn tangent to the members of the group expresses the maximum possible utilization in this engine under the conditions of the test. That this performance is very creditable is seen by consulting the scale of brake thermal efficiency which shows 25 per cent at full load and just over 20 per cent at half load.

It has been stated that with suitable carburetion the criterion $\sqrt{P}/f$, attains its maximum value on mixtures only slightly richer than those giving minimum brake specific consumption. The truth of this is shown in Fig. 5, where the value of the criterion, from the data of Fig. 4, is plotted against the brake specific consumption for the three absolute intake pressures of 350, 500 and 650 mm. of mercury.

The corresponding curves of the criterion plotted against the brake mean effective pressure are given in Fig. 6. It shows that the maximum criterion occurs not far from the maximum pressure at and below half load, and that as the load approaches its full value, the peak net performance increasingly departs from the maximum possible output.

Fig. 7 shows the relationship between this criterion and the mixture ratio for the same values of the intake pressure and indicates clearly the required variation in the fuel metering to obtain the greatest net performance from the engine.

With manual throttle control, perfectly steady and consistent operation is had throughout the throttling range when realizing the minimum possible specific fuel consumption, but it has so far been found without fail that possible maximum utilizations cannot be realized in operation under governor control. To eliminate excessive hunting, the mixtures must be enriched by an amount which results in from 5 to 10 per cent increase in the specific consumption.

JUNE COUNCIL MEETING

THE Council of the Society held two sessions at Ottawa Beach, Mich., during the Summer Meeting of the Society in June, the following being present: President J. G. Vincent, First Vice-president J. G. Utz, Second Vice-presidents W. G. Wall, A. W. Scarratt and H. C. Buffington, Past-president Charles M. Manly, Councilors E. A. De Waters, F. M. Germane, E. A. Johnston and N. B. Pope and Chairman B. B. Bachman of the Standards Committee.

The primary purpose of the convening of the Council was to consider the report of the Standards Committee in sufficient detail prior to its submission to the members of the Society in meeting assembled, with the view of taking a letter ballot of the voting members of the Society on the adoption of the various recommendations made by fourteen Divisions of the Standards Committee as a result of their deliberations since the meeting of the Society held in January.

The following transfers in grade of membership were made:

Member to Foreign Member—E. H. Lancaster, W. L. Fisher, A. A. Remington, A. J. Rowledge and Geo. H. Bechtel

Associate to Member—Douglas T. Hamilton, E. P. Reber and E. N. Sawyer

Junior to Member—M. C. Horine and H. W. Smith

The number of new members elected, as announced in the July issue of THE JOURNAL, was 214.

In connection with Standards matters, the Council directed that the Tire and Rim Division take as prompt action as possible on the question of settling upon a rim upon which 6, 7 and 8-in. pneumatic tires can be interchanged.

The following subjects were assigned to Standards Committee Divisions:

Aeronautic Division—Engine Name Plates and Thermometer Couplings

Ball and Roller Bearings Division—Shaft and Housing Fits and Tolerances for Ball Bearings

Electrical Equipment Division—Brushes

Electric Transportation Division—Front-End Nomenclature, Ribbon Resistance, Clearance Radius, Steering and Control Levers, Brakes, Industrial Truck and Tractor Storage Batteries, Generic Name and Charging Plugs

Engine Division—Carbureter Air-Cleaners and Engine Tappets

Isolated Electric Lighting Plant Division—Knife Switches

Motorcycle Division—Priming Cups and Motorcycle Wheels

Stationary Engine Division—Flywheel Pulley Lugs

Tire and Rim Division—Felloe Bands

Past-president Alden was designated as the representative of the Society on the Transportation Committee of the Federal Highway Council and nominated as a member of its Committee on Sub-Grade and Its Relation to Road Surfacing and Traffic.

F. W. Davis was appointed on behalf of the Society a member of the Automotive Conference Committee of the National Highway Educational Conference.

Standards Committee Meeting

THE 1920 Summer Meeting of Standards Committee was held at Ottawa Beach, Mich., on June 21. Fourteen Divisions of the Standards Committee reported fifty subjects, one of which was referred back for reconsideration by the Division submitting it. The reports as amended and accepted by the Standards Committee were approved by the Council and the general meeting of the Society on the same day.

The several Divisions which prepared reports have given the work careful consideration and were guided largely by opinions and data obtained through general circularization of the industries. In view of the industrial and economic conditions existing in the past six months it is felt that a large amount of good work has been accomplished which should receive the approval of the Society members in the letter ballot required for final acceptance of the reports by the Society.

The specifications approved at the Summer Meeting with a brief description of the circumstances in connection with each follow. In most cases where an existing Standard or Recommended Practice is withdrawn this is largely because the specification was adopted by the Society more or less as a war measure, having little or no commercial value at present.

Aeronautic Division

(1) *Systems of Measurement*

The present specification was intended primarily as a guide in Governmental war work and is considered suitable for commercial application in the modified form recommended. The present recommended practice is printed on page 45-o, S. A. E. Handbook, Vol. I.

The English system of measurement shall be used except in isolated cases, such as spark-plug threads, where the metric system is desirable to effect interchangeability with some well-established standard.

THE DISCUSSION

H. M. Crane:—The Aeronautic Division has not gone very far since last winter. We did not expect to do so. The greatest part of our recent work has been to overhaul the adopted Standards, ascertaining whether anything had been accomplished by their adoption. We have therefore just one new proposal regarding systems of measurement, this being probably the most important of the five recommendations we make today. In the early days of the war, there was an attempt to standardize on the metric system. Personally, I was in favor of doing this, but it was impossible then; and it seems even more impossible today. For that reason, the Aeronautic Division voted practically unanimously to recommend the accompanying revision.

(2) *Supports for Engines*

The Aeronautic Division recommends that the present S. A. E. Recommended Practice for aeronautic engine supports, page 45-o, S. A. E. Handbook, Vol. I, be withdrawn owing to the possibility of private owners replacing the engine for which an airplane is designed with an engine of different weight, as this might throw the airplane out of balance to such a degree that it would be dangerous to fly.

(3) *Shaft-Ends for Propeller Hubs*

The Aeronautic Division recommends that the present S. A. E. Recommended Practice for Shaft-Ends for Aeronautic Propeller Hubs, page 45, S. A. E. Handbook, Vol. I, be withdrawn inasmuch as it is not in accordance with present practice.

The Division is giving the subject of propeller shaft-ends considerable attention and hopes to formulate a definite recommendation based on present practice before the next meeting of the Standards Committee.

(4) *Engine Testing Forms*

The Aeronautic Division recommends that the present S. A. E. Recommended Practice for Aeronautic Engine Testing Forms, page 45qd, S. A. E. Handbook, Vol. I, be withdrawn. The present forms are the result of careful preparation but the Division feels that several revisions will make them more practical and of greater value for commercial work and intends to prepare a form in the near future covering data on engine installations which it is believed will be of great assistance to the airplane designer.

(5) *Engine Weight Specifications*

The present specifications are not considered suitable for uptodate commercial use and the Division is preparing to give this subject further careful study looking toward its revision. It is recommended that the present S. A. E. Recommended Practice for Engine Weight Specifications, page 45qg, S. A. E. Handbook, Vol. I, be withdrawn.

Automobile Lighting Division

(6) *Head-Lamp Mounting*

The Lighting Division recommends that the present S. A. E. Recommended Practice for Head-Lamp Mounting, page 38b, S. A. E. Handbook, Vol. I, be revised so as to specify a height of head-lamp centers of from 32 to 42 in. instead of from 3 to 4 ft. inasmuch as 3 ft. is about the average height of head-lamp centers; and to include a recommendation in respect to adjustments considered desirable in order that the head-lamps may be made to conform to the recommendation for head-lamp illumination. The present S. A. E. Recommended Practice revised in accordance with these changes is as follows:

> Head-lamps shall be mounted so that their centers are not less than 32 in. nor more than 42 in. from the ground. Means for adjusting the head-lamps shall be provided so as to permit a change in the vertical as well as in the horizontal angle of the head-lamps which will permit the horizontal axes to be brought parallel to the axis of the car.

THE DISCUSSION

H. M. Crane:—The report of the Automobile-Lighting Division starts with some very definite recommendations regarding head-lamp mountings and brackets, which have been worked out to conform with good practice in construction, as well as to meet the requirements of the pro-

posals regarding the safe use of head-lamps. The first proposal is to lower somewhat the height of the head-lamp mounting.

CHAIRMAN B. B. BACHMAN:—Action by the Society on this subject is far-reaching. It is one of much importance with regard to the effect of our work on outside influences, because it is very probable that the recommendations made here will be followed largely in the formulation of laws governing the operation of motor vehicles. This is a subject of great interest and should be studied very carefully.

W. R. STRICKLAND:—I would like to inquire whether the Division has looked into the patent situation and whether the field is open for the adjustments mentioned.

MR. CRANE:—The Division does not know of any reason why the requirement cannot be carried out by all. It has been common practice for a great many years to have head-lamps mounted so that they could be swung in a horizontal plane and on some cars they have been arranged to swing in a vertical plane. No reason is seen why this practice cannot be carried out by any manufacturer without infringing any patent. It is intended to permit the car owner to conform to the laws by adjusting his head-lamps to point in the proper direction. The greatest trouble with most devices is that they are rarely adjusted properly, because the owner has not usually the means at hand to adjust them.

(7) *Electric Incandescent Lamps*

The Lighting Division recommends that the present S. A. E. Standard for Bulb Sizes, page 38a, S. A. E. Handbook, Vol. I, be revised to conform to the following recommendation. This includes the present S. A. E. Recommended Practice for Focusing Lengths of Incandescent Lamps, page 38ba, S. A. E. Handbook, Vol. I, with the term "focusing length" changed to "light-center length" as this is the correct designation of the dimension involved.

The present specifications on page 38a, S. A. E. Handbook, Vol. I, are not considered adequate and the Division has therefore amplified the specification in accordance with current practice. This specification applies most generally to lamps used in gasoline automobiles and vehicles.

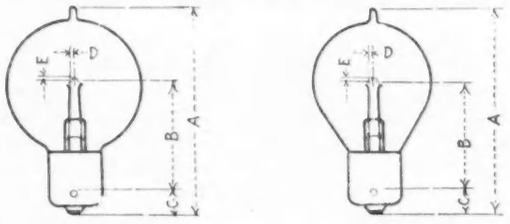
NON-FOCUSING TYPE

Number	A—Maximum Overall Length, In.	B—Maximum Distance from Top of Pin to Solder, In.
G 6	1⅜	0.299
G 8	1⅞	0.299

FOCUSING TYPE

The light-center length for all electric incandescent lamps used in head-lamps for either electric or gasoline propelled vehicles shall be 1¼ ± 3/32 in. as measured from the center of the filament field to the bulb side of the lock pins in the base.

The longitudinal axis of the lamp filament at the focal point shall not deviate more than 5/64 in. from the axis of the lamp base.



No.	A—Max. Overall Length, In.	B—Light-Center Length, In.	C—Max. Distance from top of Pin to Solder, In.	D—Variation from Axial Alignment, In.	E—Variation in Light-Center Length, In.
G8	1⅞	⅞	0.299	1/64	±3/32
G10	2¼	1⅛	0.299	1/64	±3/32
G12	2½	1¼	0.299	1/64	±3/32
G16½	3⅛	1¼	0.299	2/64	±3/32
S11	2½	1¼	0.299	1/64	±3/32

It is recommended that these deviations be reduced by the incandescent lamp manufacturers so that the allowable deviations of the filament field from the axis of the base is no greater than one-half of the base of the filament field for any type of incandescent lamp.

(8) *Head-Lamp Nomenclature*

Several of the definitions under this subject have been reworded for clarity's sake and it is recommended that they be revised as follows:

The definition for the base reading: "The base is that portion of the electric incandescent lamp by means of which it is retained in the socket," should be revised to read, "The base is that portion of the electric incandescent lamp by means of which the lamp is retained in the socket and the electrical contact made."

The definition for focusing length should be changed to a definition for light-center length revised to read: "The light-center length is the distance along the axis of the base from the center of the filament field to a plane perpendicular to the axis and passing through the bulb side of the lock pins." This change is recommended as the definition is intended to refer to that dimension known as the light-center length, the focusing length being a dimension dependent upon the shape of the reflector.

The definition for the glass bulb should be revised to read "The glass bulb is designated in regard to shape, as 'round' (G) or 'straight-side' (S); and in regard to size, in eighths of an inch. For example, an S-11 bulb is a straight-side, 1⅛-in. diameter bulb." This definition includes the designation of the straight-side bulb which has been added to the standard for electric incandescent lamps.

The definition for the apex reading, "The apex is that portion of the reflector at the extreme rear," should be revised to read, "The apex is the portion of the reflector at the smallest diameter."

(9) *Head-Lamp Brackets*

The Lighting Division recommends that the present S. A. E. Recommended Practice for Head-Lamp Brackets, page 38b, S. A. E. Handbook, Vol. I, be revised so as to include a 6-in. center-to-center width for the fork-type head-lamp bracket, this size being used to a considerable extent in truck practice. The Division also recommends

the adoption of two proposals covering the fender and hollow-prop types of head-lamp brackets. The present S. A. E. Recommended Practice extended to include these proposals is as follows:

Fork Type The fork-type head-lamp brackets shall have center-to-center widths of 6, 7¼, 8¼ and 9¼ in. The upper ends of the fork shall be ½-in diameter with ½-20 S. A. E. thread. Shoulders shall be machined to not less than ¾-in. diameter. The distance from the upper face of the shoulder to the last full thread on the ends of the fork shall be not less than 1½ in. where no tie-rod is used or 1½ in. plus the thickness of the rod where a tie-rod is used. The use of nuts and lock washers for locking lamps to the fork is recommended.

The lugs attached to the lamp housing shall have bores 17/32-in. diameter and 1½ in. long. The center-line of the holes in the lugs shall be not less than 9/16 in. from the nearest point of the lamp housing. The clearance between the lower part of the bracket and the lamp housing shall be not less than 9/16 in.

Fender Type The fender-type head-lamp bracket shall be attached to the outside of the lamp body and the center-to-center distance of the bolt holes shall be 3 in. The bolt holes shall be 13/32 in. wide and ¾ in. long. The mounting surface of the fender bracket shall be parallel to the axis of the lamp and no tie-rod lugs shall be made integral with the lamp body.

Hollow-Prop Type The shank of the hollow-prop type head-lamp bracket shall be 1 1/16-in. diameter and 2 in. long.

(10) *Head-Lamp Lighting Nomenclature*

At the time this definition was prepared the endeavor was made to secure a sharply defined straight beam of light, which has been demonstrated in subsequent tests and experiments to be undesirable. It is therefore recommended to omit the word "unintentionally" from the definition so that it will be in conformity with the revised head-lamp illumination specification submitted below. (Item No. 11.)

The revised S. A. E. Standard for Head-Lamp Lighting Nomenclature, page 38b, S. A. E. Handbook, Vol. I, will read, "Stray direct light is the light changed in direction by the reflection from bulb parts."

(11) *Head-Lamp Illumination*

The report of the Automobile Lighting Division made to the Standards Committee in January 1920 stated that observations indicated that a minimum illumination of 4800 apparent cp. at some point between points *A* and *B*, given in the accompanying illustration, was satisfactory as a legal requirement, but that a higher value should be specified for S. A. E. Recommended Practice; and that the Division planned additional tests in cooperation with the Committee on Automobile Headlighting Specifications of the Illuminating Engineering Society.

As a result of this joint work the Automobile Lighting Division now recommends that the present S. A. E. Recommended Practice for Head-Lamp Illumination, page 38b, S. A. E. Handbook, Vol. I, be extended to include a minimum road illumination of 4800 apparent cp. and the laboratory test proposed for new equipment. The present S. A. E. Recommended Practice extended as proposed follows:

OPERATING REQUIREMENTS

The head-lamps shall be arranged so that under normal conditions of vehicle loading

(1) The light produced on the level surface on which the vehicle stands at a distance of 200 ft. directly in front of the vehicle and at some point between the level surface and a point on a level with the centers of the lamps shall be not less than 4800 apparent cp.

(2) The light produced at a distance of 100 ft. directly ahead of the head-lamps and at a height of 60 in. or more above the level surface on which the vehicle stands shall not exceed 2400 apparent cp.

(3) The light produced 100 ft, ahead of the vehicle and 7 ft. or more to the left of its axis and at a height of 60 in. or more above the level surface on which the vehicle stands shall not exceed 800 apparent cp.

(4) The light produced 100 ft. ahead of the vehicle and at some point between the level surface on which the vehicle stands and a point on a level with the centers of the lamps and 7 ft. to the right of the axis of the vehicle shall be not less than 1200 apparent cp.

LABORATORY PERFORMANCE TEST OF NEW HEAD-LAMP EQUIPMENT

The combined beam of two head-lamps tested under laboratory conditions shall conform to the following limitations when equipped with either a vacuum-type lamp of 15 measured mean spherical cp. or with a gas-filled-type lamp of 21 measured mean spherical cp. at the following points:

A—Directly in front of the vehicle on a level with the lamps

B—Directly in front of the vehicle 1 deg. below the level of the lamps

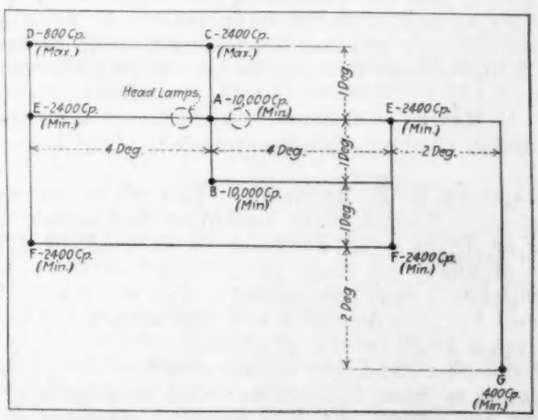
C—Directly in front of the vehicle 1 deg. above the level of the lamps

D—Four degrees to the left of the vehicle and 1 deg. above the level of the lamps

E—Four degrees to the right and left of the vehicle and on the level of the lamps

F—Four degrees to the right and left of the vehicle and 2 deg. below the level of the lamps

G—Six degrees to the right of the vehicle and 4 deg. below the level of the lamps



LOCATION OF POINTS SPECIFIED IN PERFORMANCE TEST

For the points listed on page 197 the limitations shall be as follows:

At points *A* and *B* or at some point between them the apparent candlepower shall be not less than 10,000

At point *C* the apparent candlepower shall not exceed 2400 nor shall this value be exceeded at points beyond point *C*

At point *D* the apparent candlepower shall not exceed 800 nor shall this value be exceeded at points above point *D*

At or between the points *E* and *F*, both right and left, the candlepower must be at least 2400 and in the rectangle *EEFF* the candlepower at any point on any horizontal line parallel to *EE* shall be not less than the candlepower at the intersections of such line with the line *EF*

At point *G* the apparent candlepower shall be not less than 400

It is desirable that there should not be a sharp cut-off of the light between the points *A* and *C*, but that it should shade off gradually. The candlepower at point *C* should therefore not be much less than the maximum allowed.

It is not intended that these values should be used for the purpose of legal restrictions of head-lamps on the road, but should be confined in their application to laboratory tests of new equipment which is in first-class condition and giving its maximum performance.

THE DISCUSSION

H. M. CRANE:—This report of the Division is probably the most important part of its work. We have all suffered in a greater or less degree of silence on the subject of proper lighting of automobiles. We gravitated first in the direction of having no light at all and then of having too much. The Division, in conjunction with the Illuminating Engineering Society, has endeavored to reach a satisfactory compromise. I cannot emphasize too strongly that this work can only be a compromise. There is no possible way in which to get an unlimited driving light and still have no glare.

C. R. ALLING:—Does this standard comply with the present laws of California and Wisconsin?

MR. CRANE:—There are undoubtedly certain State laws at the present time that would not be exactly met by this proposal. There are very few of the older laws that were definite enough.

MR. ALLING:—I understand that Wisconsin has recently passed a law developed as a result of extensive experiments, taking into account the activities of the Illuminating Engineering Society.

MR. CRANE:—I believe that the Illuminating Engineering Society and the Automobile Lighting Division are in absolute agreement on this proposition. If the Wisconsin law conforms with the recommendations of the former it will undoubtedly be found in agreement with this proposal.

W. S. HARLEY:—The recommendation of the Division is, I think, identical with the provisions of the Wisconsin law.

CHAIRMAN B. B. BACHMAN:—This whole subject of illumination touches every individual that makes, sells, owns or drives a car, or walks in the road. I do not know of any other single thing regarding which more worthless laws have been passed and on which more foolish work has been done than this very subject. It should be given a great amount of attention.

On the other hand, I do not know that we are bound by the action of State legislatures. Our function is to try to work out something that is practical and takes all the related elements into account. After that has been done, the law-making bodies if they see fit to take advantage of the work that we have accomplished will, in all probability, have something that is very good. If they do not accept these results we cannot help it; we will, at least, have done our part. If we do not do this work properly, we cannot expect them, who are totally unqualified in many respects to pass on the technical phases of the matter, to provide good legislation.

J. E. SCHIPPER:—Is not the 60-in. height greater than has been customary? I understand that 48 in. has been generally considered standard.

MR. CRANE:—I believe the New York law was the first in which the 60-in. height was specified. The 48-in. was provided for in the older law. Due to irregularities of road surface, the low limit is a serious disadvantage. The requirements of this proposal are worked out more with a view to protecting the driver when approaching the automobile and not necessarily to protect a man or a child walking on the road.

There are two points that I might mention in connection with this matter: first, the requirement of 10,000 minimum cp. and second, the attempt made to get diffused light on the sides of the road, which the early S. A. E. recommendations did not provide for. We first attempted to obtain a very powerful centralized light on the road surface, which blinded the driver to anything that was not directly within the radius of that beam. The attempt now is to have light as far as possible on every part of the road, keeping within limits that will not blind an approaching driver. The beam that is expected to reach the approaching driver is that of 800 cp. On the other or right side of the road, the considerably higher candlepowers are permitted.

W. C. KEYS:—The words "light produced 100 ft. ahead of the vehicle," should it seems to me, read "light produced 100 ft. from the front of the head-lamp." I can imagine getting into a controversy with an officer, figuring on measuring from the center of the vehicle, center of the wheel-base, or something of that sort.

MR. CRANE:—I think that is a fair criticism. On the other hand, officers are not going to appear with apparatus to measure candlepower and probably one expression is about as indefinite as the other. I think it might be wiser, however, to make it a little clearer in that regard.

I would like to call attention to the fact that this report rather definitely militates against the diffusing type of head-lamp. If any one wants to speak up for that type, this is a good chance to do so. The New York law so definitely militated against the diffusing head-lamp that it would have practically put it out of use if it had not been for the special dispensation of the Secretary of State, allowing a much higher candlepower with that type.

CHAIRMAN BACHMAN:—I am glad Mr. Crane called that to your attention, because it is something you have to take into consideration. The people that are using the diffusive type of lens will probably take severe exception to some of these provisions.

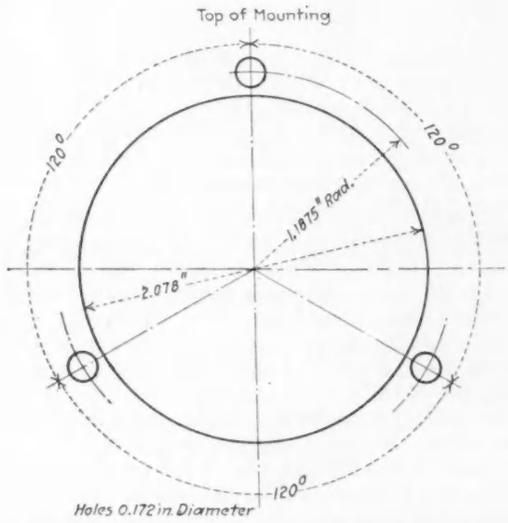
ELECTRICAL EQUIPMENT DIVISION

(12) *Electrical Instrument Mounting Dimensions*

The Electrical Equipment Division has given a great amount of consideration to the standardization of mounting dimensions for electrical instruments and oil gages. Active work on this subject started in April 1918 by the appointment of a Subdivision for the preparation of a proposal which was circularized among the automobile and instrument manufacturers. The proposal was subsequently revised and again circularized, and the replies

considered by the Electrical Equipment Division. It was thought at that time that the specification as drafted would not be acceptable to the industries. The matter was again referred back to the Subdivision, which held a meeting on Oct. 2, 1919, with electrical instrument and gage manufacturers, including representatives of the Splitdorf Electrical Co., W. G. Nagel Electric Co., Roller-Smith Co., Weston Electrical Instrument Co. and the National Gauge & Equipment Co. A revised specification was agreed to by those present, which was circularized and endorsed by a large number of automotive manufacturers. The recommendation now presented by the Division for adoption as S. A. E. Standard conforms with the Subdivision specification with regard to the diameter of the hole in the dash for the body of the instrument and gage, and the diameter and location of the holding screw holes. It is felt by the Division that this is as far as the standard should go at the present time to be of greatest value and that other details can be included as future conditions may warrant.

The Division recommendation is intended for oil gages as well as for electrical instruments.



ELECTRICAL INSTRUMENT AND GAGE MOUNTING DIMENSIONS

THE DISCUSSION

A. D. T. LIBBY:—The report as summarized in the diagram was worked out, as the best recommendation that can be had at the present time in connection with the mounting of meters. It was thought there might be two standards, one for small instruments and one for larger instruments, but the Subdivision did not feel that two standards were desirable.

ELECTRIC TRANSPORTATION DIVISION

(13) *Clearance Radius*

There has been considerable difference in practice and consequently much misunderstanding as to the definite method of measuring the clearance radius of industrial trucks and tractors. The Industrial Truck and Tractor Subdivision of the Electric Transportation Division has prepared a definition for this method of measuring. The report was amended at the Standards Committee meeting to cover outside clearance radius, as well as inside clearance radius.

The Electric Transportation Division therefore recommends for adoption as S. A. E. Recommended Practice that the terms "outside clearance radius" and "inside clearance radius" shall be used to designate respectively the turning radius of the extreme outside and inside points of the vehicle and that these radii shall be shown on dimensioned illustrations in catalogs, etc.

THE DISCUSSION

E. L. CLARK:—The reason for this recommended standard is that different manufacturers designate the turning or clearance radius as from different parts of the vehicle. Sometimes it is the outside wheel, sometimes the platform. The platform is the important feature in determining the clearance radius of an industrial truck.

W. C. KEYS:—When one of these vehicles is turning from one aisle into another in a factory, it is important to know that it will clear inside as well as outside of the platform. Manufacturers' catalogs are diagrammed showing both the outside and inside clearance radii.

MR. CLARK:—In connection with the inside radius the point was raised at the meeting of the Division that it seldom comes into consideration and is not worthwhile establishing such a standard.

JOHN MCGEORGE:—The inside clearance radius is important. Manufacturers themselves are to be blamed, because in their anxiety to show a short outside clearance, some began giving the center line and others the outside radius of the wheels, thus confusing the practice. I approve heartily of the suggestion to add the inside clearance radius to the recommendations of the Division. I think it will clarify the situation very much particularly with regard to the customers.

MR. KEYS:—The point I wish to make is that intersecting aisles in a factory cannot be laid out where there are posts and pillars to clear unless it is known that the industrial tractor will clear at the turns. The two dimensions mentioned are necessary for this purpose. Including the terms "outside or maximum radius swept by any part of the vehicle in making its shortest turn" and "the minimum or inside clearance radius" will make the recommendation comprehensive.

(14) *Brakes*

Much confusion and danger of accidents in the operation of industrial trucks and tractors have been occasioned by the variation in the method of operating brakes. The Subdivision and Division have given this careful attention and recommend for adoption as S. A. E. Recommended Practice that brakes for industrial trucks or tractors shall be constructed so that they are released by depressing the brake pedal and applied by removing the foot. The method of applying brakes by means of the operator leaving the seat is disapproved and should be discontinued.

THE DISCUSSION

E. L. CLARK:—There are some differences, as I understand it, in the design of different industrial trucks. Some have brakes that are released by depressing the foot and others by raising it. This recommendation is to establish, if possible, a standard practice which will eliminate confusion when the operator changes from one vehicle to another, thereby avoiding accidents.

CHAIRMAN B. B. BACHMAN:—What is the present practice on this matter, Mr. Clark?

MR. CLARK:—In the majority of cases, the brake is released by pressing down on the foot pedal, so that

when the operator is standing on the truck, his foot is on the pedal and the brakes are released.

(15) *Storage Battery Trays*

One of the items of industrial-truck practice and operation is the lack of uniformity in battery and battery tray dimensions and arrangement. The need of standard practice has been felt particularly in operation and service, and after a careful analysis of the situation the Division recommends for adoption as S. A. E. Recommended Practice that for lead batteries one type of tray of twelve cells be adopted for both industrial trucks and tractors; batteries for industrial trucks to consist of one tray unit, and batteries for tractors to consist of two tray units.

THE DISCUSSION

E. L. CLARK:—The reason for this standard is the idea of eventually working to uniform battery compartments for trucks and tractors. The endeavor was made to establish certain limiting dimensions for the two cases, but it was decided that it is too soon to do this, on account of certain limitations. It was, however, proposed to establish a unit of twelve cells which can be used in both the trucks and the tractors, using one unit for the trucks and two units in the tractors.

JOHN MCGEORGE:—May I ask why the Edison battery is ignored in the S. A. E. Handbook. A question came up the other day regarding the Edison batteries, and when I referred to the Handbook there was nothing there on it. This comes up with regard to this battery recommendation.

MR. CLARK:—The reason is this that the Edison battery has certain dimensions that are already determined, and there is only one Edison battery. The lead batteries are of several different makes and vary in dimensions. In this report it is intended to standardize only the number of cells in the tray.

MR. MCGEORGE:—The question was, Why is the Edison battery ignored entirely in our Handbook? Why are there no charging instructions? Full particulars of the lead batteries are given.

R. S. BURNETT:—The matter of storage-battery instructions, as we call it, comes under the Electrical Equipment Division which is now working in conjunction with the battery and vehicle manufacturers and the Government to bring the S. A. E. Standards up to date.

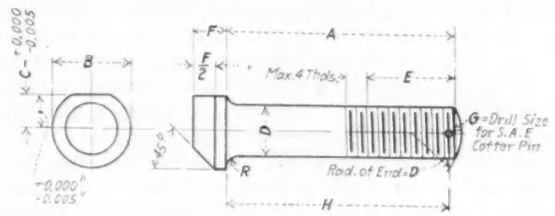
ENGINE DIVISION

(16) *Connecting-Rod Bolts*

Data obtained from a large number of companies representing the passenger-car, commercial-vehicle, stationary engine, tractor and marine industries show that there are about seventy-five different sizes of connecting-rod bolts used at the present time. The Division found, however, that about 75 per cent of these were similar in head design, and these types were therefore used as a basis for the standard proposed. The proposed thread tolerances are in agreement with the tentative report of the National Screw Thread Commission and the body diameter limits are intended to provide a reasonable driving fit of the bolts in reamed holes.

The original proposal which was referred back at the Standards Committee Meeting last January and contained only three sizes has been revised and extended as shown in the accompanying table.

The Engine Division believes that the standard now proposed for adoption will be of particular value to manufacturers of screw-machine products who are at present called upon to produce an unnecessarily large number of connecting-rod bolt types and sizes.



Diam.	A	B	C	D	Threads S.A.E.	Pitch Diam.	E[1]	F	G No.	H	R
5/16	Lengths Vary by Even 1/8 In. Preferably by 1/4 In.	5/16	5/16	0.3125 / 0.3105	24	0.2854 / 0.2830	1/2	5/16	48	A-5/32	0.01 to 1/32
3/8		5/8	7/32	0.3750 / 0.3730	24	0.3479 / 0.3455	5/8	1/2	36	A-2/4	
7/16		11/16	1/4	0.4375 / 0.4355	20	0.4050 / 0.4024	11/16	1/4	36	A-2/4	
1/2		3/4	9/32	0.5000 / 0.4975	20	0.4675 / 0.4649	3/4	9/32	36	A-2/4	1/4 to 1/4
5/8		7/8	5/16	0.5625 / 0.5600	18	0.5264 / 0.5234	7/8	5/16	28	A-7/16	
3/4		1	3/8	0.6250 / 0.6220	18	0.5889 / 0.5859	1	3/8	28	A-7/16	
7/8		1 3/8	7/16	0.7500 / 0.7470	16	0.7094 / 0.7062	1 3/8	7/16	28	A-7/16	1/32 to 1/16
1		1 3/8	1/2	0.8750 / 0.8715	14	0.8286 / 0.8250	1 1/4	1/2	28	A-7/16	
		1 1/2	5/16	1.6000 / 0.9965	14	0.9536 / 0.9500	1 1/2	5/8	28	A-1/4	

Threads are U. S. Form
[1]Minimum Length of Usable Threads.
Recommended practice for material is S.A.E. steel Spec. No2. 330 or 3130.Heat treatment should give a Brinell test of from 223 to 285.

THE DISCUSSION

H. C. SNOW:—At the January meeting of the Society the Engine Division presented a recommendation on connecting-rod bolts of three diameters, 3/8, 7/8 and 1 1/2 in. There were some criticisms that this did not cover the field widely enough. Also, there were criticisms on a few of the dimensions. So the recommendation was referred back to the Division. This has been revised by adding the 5/16-in. size and the sizes from 1/2 to 1 in. and by changing the radius under the head for the different sizes. It was explained at the previous meeting that these sizes were selected as the averages of various bolts used by the engine manufacturers.

TEMPORARY CHAIRMAN J. G. UTZ:—In connection with standards work where limits are specified there is frequently criticism on the basis that the limits cause some difficulty in the application of the standard. This has probably been well considered by the Division and should be considered by the Standards Committee as a whole.

E. H. EHRMAN:—When this subject was under consideration there was no criticism whatever of the limits, and no change has been made in the limits.

IRON AND STEEL DIVISION

(17) *Valve Metals*

The Iron and Steel Division recommends that the present S. A. E. Standard for Valve Metals, page 10, S. A. E. Handbook, Vol. I, be withdrawn as it has been ascertained that these valve metals are not used to any extent in present practice, cast iron, 3-per cent nickel, or tungsten steel generally being used for this purpose.

THE DISCUSSION

H. J. STAGG:—Regarding valve metals the manufacturers were very carefully canvassed with a view to finding out how much and how many of the materials which were then specified as S. A. E. Standards of valve metal

were being used. It was found that some of the materials were used very little and therefore some unnecessary and useless specifications were omitted in our present recommendation.

(18) *Tungsten Steels*

The Iron and Steel Division has carefully studied the question of numbering steel specifications, having drawn up a skeleton numbering system which will accommodate any probable combinations of known elements. In order that the present steel specification numbers may conform to this arrangement the Iron and Steel Division recommends that tungsten steel Specifications No. 7060 and 7160 be changed to No. 71360 and 71660 respectively.

THE DISCUSSION

H. J. STAGG:—A tentative schedule has been considered for renumbering the S. A. E. steel specifications but it has not as yet been approved. However, in order that the new tungsten valve steels can be classified in accordance with the proposed new numbering, it is recommended that the numbers be changed from 7060 and 7160 to 71360 and 71660.

(19) *Nickel Steels*

Nickel steel Specification No. 2512, containing from 4.50 to 5.25 per cent nickel and adopted by the Society in March, 1920, has been criticised to the effect that it is very difficult to machine after it has been carburized. The Iron and Steel Division therefore recommends that the following note applying to Specification No. 2512 be added to the present S. A. E. Standard for Nickel Steels, page 9a, S. A. E. Handbook, Vol. I, and under the Notes and Instructions pertaining to nickel steels:

> When it will be necessary to machine parts made according to Specification No. 2512 after carburizing, the nickel content should be maintained as close to the lower limit as feasible.

MISCELLANEOUS DIVISION

(20) *Brake Linings*

BRAKE LINING WIDTHS AND THICKNESSES

Width, In.	Thickness, In.				
	3/32	1/8	1/4	5/16	3/8
1	*				
1 1/8	*				
1 1/4	*				
1 1/2	*	*			
1 3/4	*	*	*		
2	*	*	*		
2 1/4	*	*	*	*	
2 1/2		*	*	*	
2 3/4			*	*	*
3			*	*	*
3 1/2				*	*
4				*	*
4 1/2					*
Tolerances, In.	+0.000 −0.020	+0.000 −0.020	+0.000 − 1/32	+0.000 − 1/32	+0.000 − 1/32

The present specification printed on page 26c, S. A. E. Handbook, Vol. I, was adopted by the Society in August, 1915. Practice has changed considerably since that time and the Division after a careful review of the brake linings used in current practice recommends that the present standard be revised as indicated below. In preparing this revision the Division considered the probable trend of future practice in connection with brake linings for all types of automotive apparatus. It is realized that there are sizes used to some extent which have not been included in the specifications, but it was felt that the standard should indicate the sizes to be used only in most general practice. The recommendation eliminates the following sizes specified in the present S. A. E. Standard: 1/8 by 1, 1/8 by 1 1/4, 1/8 by 1 1/2, 3/16 by 1, 3/16 by 1 1/4, 1/4 by 1, 1/4 by 1 1/4, 1/4 by 1 1/2, 5/16 by 1 1/2, 5/16 by 1 3/4, 5/16 by 2, 3/8 by 2, 3/8 by 2 1/4 and 3/8 by 2 1/2. The recommendation adds the following sizes which are widely used in present practice: 5/32 by 1, 5/32 by 1 1/8, 5/32 by 1 1/4, 5/32 by 1 1/2, 5/32 by 1 3/4, 5/32 by 2 and 5/32 by 2 1/4. The 5/32 by 1 1/8-in. size has been included in the recommendation as it will probably be widely used by motorcycle manufacturers.

THE DISCUSSION

E. H. EHRMAN:—The Miscellaneous Division reviewed the present brake-lining schedule and prepared a list of sizes most generally used today, reducing the number to the lowest possible limit for a standard consistent with the requirements of the industry.

(21) *Oil and Grease-Cup Threads*

The Miscellaneous Division recommends for adoption as S. A. E. Recommended Practice the following oil and grease-cup threads which are widely used in present practice. The Division feels that the adoption of this proposal will aid materially in doing away with the large number of special sizes which are specified at the present time.

S. A. E. FINE THREAD		AMERICAN STANDARD TAPER PIPE THREAD	
Diameter	Threads per Inch	Nominal Size	Threads per Inch
1/4	36	1/8	27
5/16	32	1/4	18
		3/8	18
		1/2	14

THE DISCUSSION

E. H. EHRMAN:—In connection with oil and grease-cup threads, the Division thought it wisest not to have parallel sizes. Therefore all grease-cup threads smaller than 3/8 in. in diameter are straight and all larger diameters conform with the standard American taper pipe thread.

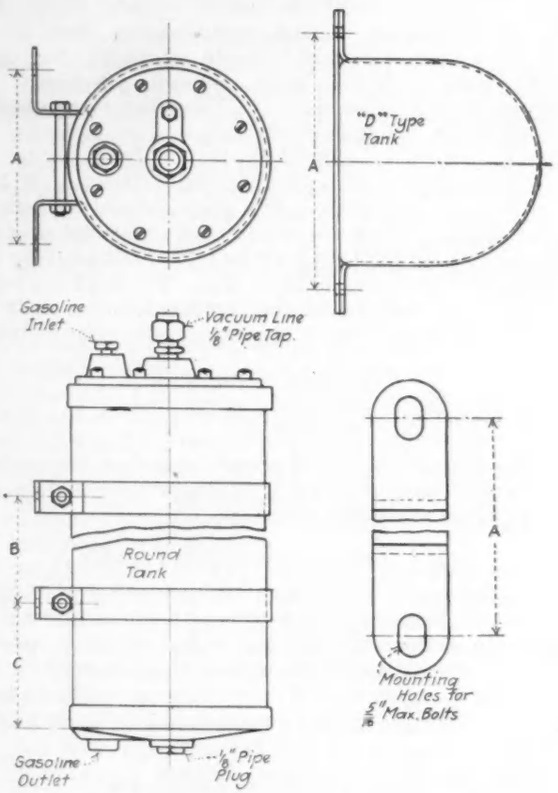
J. G. ZIMMERMAN:—Has the committee considered the threads of the cap end of the grease-cup, which seems to me are important?

MR. EHRMAN:—The purpose of this specification is to make grease-cups interchangeable as far as their application is concerned. No attention has been given to standardizing the cap threads or other components of the cups.

(22) *Fuel Vacuum Tank Mounting*

The Miscellaneous Division recommends that the present S. A. E. Recommended Practice for Fuel Vacuum Tank Mounting and Connections, page 35da, S. A. E. Handbook, Vol. I, be revised so as to permit the use of 5/16-in. bolts. The revision also shows the mounting holes in the straps elongated to facilitate mounting where the bolt holes in wooden dashes are liable to considerable variation in location. The new specification will permit

the use of smaller bolts if desired and is in accordance with present practice.



FUEL VACUUM TANK MOUNTING

MOTORCYCLE DIVISION

(23) *Motorcycle Fuel and Lubrication Pipe Fittings*

Inasmuch as the present S. A. E. Recommended Practice for Motorcycle Fuel and Lubrication Pipe Fittings, page 55, S. A. E. Handbook, Vol. I, is the result of careful investigation and development and is now used extensively in the industry, although in some cases with slightly different dimensions, the Motorcycle Division recommends that the recommended practice be revised by the elimination of the word "military" so as to apply to commercial practice. The Division plans to extend this proposed standard to include 3/16, ¼ and ⅜-in. diameter tubing at a later date.

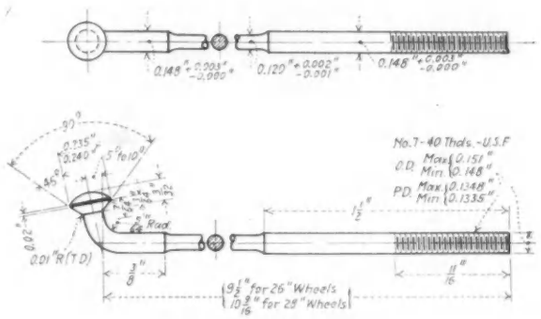
(24) *Oil and Grease-Cups*

The present S. A. E. Recommended Practice for Oil and Grease-Cups, page 55, S. A. E. Handbook, Vol. I, was adopted for military practice and in view of the fact that the Miscellaneous Division has proposed the standardization of oil and grease-cup threads the Motorcycle Division recommends that this specification be withdrawn.

(25) *Motorcycle Spokes and Nipples*

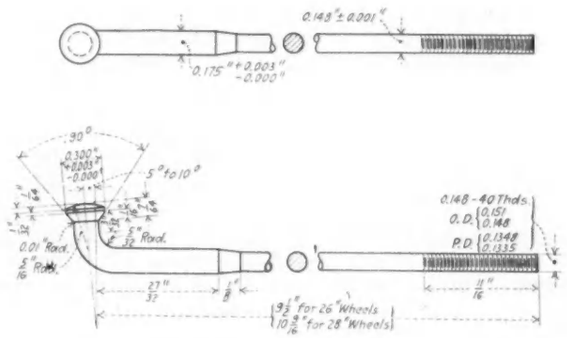
The Motorcycle Division recommends that the present S. A. E. Recommended Practice for Motorcycle Spokes and Nipples, page 8m, S. A. E. Handbook, Vol. I, be extended to include the heavy type of spoke which has recently been developed by the motorcycle manufacturers in cooperation with the spoke manufacturers. This type of spoke is from seven to eight times stronger than the present standard spoke as determined from tests on a vibrating machine which come as near as possible to duplicating the stresses set up in a motorcycle wheel when in motion. The heavy-type spoke has the same body, threaded end and nipple dimensions as the present spoke, the differences being in the diameter of the spoke body and dimensions of the head end.

The Division also recommends, inasmuch as the present S. A. E. Recommended Practice has been widely adopted and has proved satisfactory in service, that it be adopted as S. A. E. Standard. The present specifications covering spoke dimensions and chemical specifications and tests have been combined into a single complete specification.

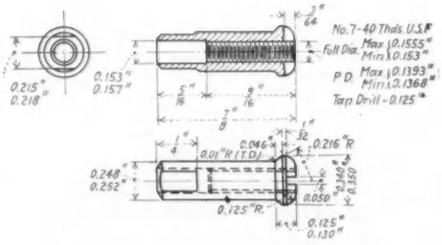


9½" for 26" wheels
10 9/16" for 28" wheels

Light-wheel type spoke



Heavy-wheel type spoke



Nipple

Tolerances specified are without plating.

Threads may be either cut or rolled, but the unthreaded portion of the butt must remain 0.148 in. + 0.003 — 0.000.

The nipple is to be made from free-cutting screw-stock and is to be finished according to dimensions.

Spoke Wire Specifications

The spoke wire shall have the following chemical content in percentage within the limits specified:

Carbon .....0.40 to 0.55
Manganese, not under..0.50
Phosphorus, not over ...0.05
Sulphur, not over 0.05

Tolerance of Diameter

The nominal wire diameter must be 0.148 in. + 0.000 — 0.001.

Bend Test

The wire must be held firmly in a pair of jaws so that it may be bent over a surface having a radius of one-half the nominal diameter of the wire, and shall stand a test of at least four bends, counted as follows. Holding the free length of the wire loosely between clamps so that it cannot bend except at the holding jaws, it is to be bent 90 deg. over one jaw; this to be counted as one bend. It is then to be bent up to its original position; this to be counted as the second bend. It is then to be bent 90 deg. to the other side, third bend, and back to its original position to complete the test.

Tensile Strength

The tensile strength of the wire is to be not less than 140,000 lb. per sq. in.

Physical Tests

[1]Tensile Strength

The finished light-type spoke, when held at the bent end in the same manner as by the hub flange in a finished wheel and at the threaded end by a standard nipple with the spoke threads filling all the nipple threads, must sustain a dead load of not less than 1580 lb.

Torsion Test

This test is not required.

(26) *Cylinder Displacement*

The present S. A. E. Recommended Practice for Cylinder Displacement, page 56a, S. A. E. Handbook, Vol. I, was adopted primarily for military practice. As this specification is not considered suitable for commercial practice because it limits design, the Motorcycle Division recommends that it be withdrawn.

(27) *Carrying Capacity*

As the present S. A. E. Recommended Practice for Carrying Capacity, page 55a, S. A. E. Handbook, Vol. I, was also adopted for military practice and is of no value as a commercial standard, the Motorcycle Division recommends that it be withdrawn.

(28) *Motorcycle Tires*

The Motorcycle Division also recommends that the present standard for Motorcycle Tires, page 56a, S. A. E. Handbook, Vol. I, be withdrawn, as the standard is included in the present S. A. E. Standard for Motorcycle Tires, page 8k, S. A. E. Handbook, Vol. I.

(29) *Kick Starters*

The Motorcycle Division recommends that the present S. A. E. Recommended Practice for Kick Starters, page 56, S. A. E. Handbook, Vol. I, be withdrawn, as it limits design and is not considered of value as a standard.

Roller Chain Division

(30) *Roller Transmission Chains—Heavy Series*

The present S. A. E. Recommended Practice for Roller Chain Dimensions, page 14c, S. A. E. Handbook, Vol. I, was adopted by the Society in January, 1918 as a temporary means of unifying practice with the least disturbance to the industry during the war. The specification was prepared jointly by the Committee on Roller Transmission Chains of the American Society of Mechanical Engineers and the Roller Chain Division with the intention of revising and extending the recommendation to cover commercial practice when war production conditions were over.

The report which was submitted to the Standards Committee Meeting last winter was, however, referred back, due to lack of proper consideration at that time. It has subsequently been carefully considered in connection with chain users' requirements and insofar as possible with future practice, and the Joint Committee has prepared the following recommendations for heavy, medium and light roller chain dimensions and the Roller Chain Division presents them for adoption as S. A. E. Standards.

The Joint Committee has considered the work of the Association of British Driving Chain Manufacturers toward establishing insofar as possible an international standard. Compromises have been made by both the American and British Associations and the specifications now presented are uniform with a few exceptions. It is felt, however, that the present proposal represents the best standard that can be adopted by American manufacturers and users.

[1]It was voted at the Standards Committee Meeting to include in this test the minimum dead load for the heavy-type spoke as soon as it is determined.

HEAVY ROLLER TRANSMISSION CHAIN DIMENSIONS

Pitch	Roll Diameter	Pin Diameter	Thickness of Inside Plates	W—Chain Width, Minimum	Measuring Load, Lb.	Approximate Test Load, Lb.
3/8	0.250 (1/4)	0.125 (1/8)	0.050	0.250 (1/4)	14	464
1/2	0.3125 (5/16)	0.156	0.060	0.3125 (5/16)	25	825
5/8	0.400	0.200	0.080	0.375 (3/8)	39	1280
3/4	0.469 (15/32)	0.234 (15/64)	0.094 (3/32)	0.500 (1/2)	56	1850
1	0.625	0.3125	0.125 (1/8)	0.625 (5/8)	100	3300
1 1/4	0.750 (3/4)	0.375	0.156 (5/32)	0.750 (3/4)	156	5150
1 1/2	0.875 (7/8)	0.4375 (7/16)	0.1875 (3/16)	1.000	225	7430
1 3/4	1.000	0.500 (1/2)	0.220	1.125 (1 1/8)	325	10700
2	1.125	0.5625 (9/16)	0.250 (1/4)	1.250 (1 1/4)	400	13200
2 1/2	1.550	0.781 (25/32)	0.3125 (5/16)	1.5625(1 5/16)	625	20600
3	1.900	0.9375 (15/16)	0.375 (3/8)	1.875 (1 7/8)	900	29700
4	2.500	1.250	0.500 (1/2)	2.500 (2 1/2)	1600	52800
5	3.000	1.500	0.625 (5/8)	3.000	2500	82500
Formulas	Approximately 5/8 P	Approximately 1/2 roll diameter	1/8 P	Approximately 0.625 P	100 P^2	Approximately 3300 P^2 or 1/5 breaking strength

(31) *Roller Transmission Chains—Medium Series*

The medium series of roller transmission chains for any given pitch shall use the roller, bushing and pin dimensions for the next shorter pitch of the heavy series.

(32) *Roller Transmission Chains—Light Series*

The light series of roller transmission chains for any given pitch shall use the roller, bushing and pin dimensions for the second shorter pitch of the heavy series.

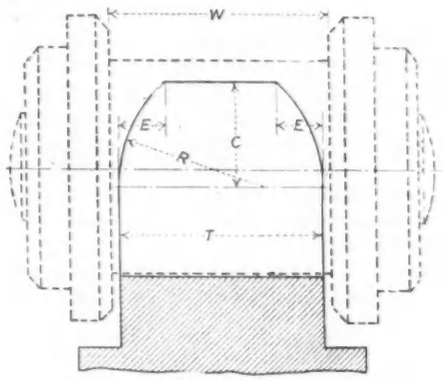
THE DISCUSSION

G. M. BARTLETT:—The Roller Chain Division has been working continuously in conjunction with the Standards Committee of the American Society of Mechanical Engineers, and the recommendations here presented are those of both committees. The standards here proposed affect five dimensions on steel roller chains, namely, pitches, roller diameters, widths, thickness of the inside plates and the pin diameters. The series of pitches is the same series that is now in use. The roller diameters are the same as are now in use on the most approved types of driving chains. The widths differ from those now in use only by a few thousandths of an inch to obtain uniformity. The thicknesses of side-plates are, in most cases, the same as now in use. Where they are changed the object is to effect interchangeability of spare parts. Pin diameters are, in most cases, the same as now in use, one exception being that of the ¾-in. pitch, in the case of which it was impossible to adopt any of the sizes now in use that seemed to be desirable, because each manufacturer makes a different size; so the diameter adopted was that nearest to the size that was found to be most desirable, namely about five-sixteenths of the pitch. These dimensions were chosen with the idea of getting as nearly ideal proportions as possible. For instance, the particular widths proposed are those nearest to the ones now in use that are about five-eighths of the pitch. The roller diameters are as near to five-eighths of the pitch as those now in use will allow. The thickness of the side-plates is as close to one-eighth of the pitch as possible in considering present practice. Aside from these five features, which will insure interchangeability of chains on sprockets and also interchangeability of spare parts or connecting links on chains of different makes, it is proposed to suggest a standard measuring load, under which the length of the chain shall be measured. This measuring load is approximately 100 times the square of the pitch, or about 1 per cent of the ultimate breaking strength of the chain. The test load proposed as a standard is about one-third of the breaking strength of the chain.

CHAIRMAN B. B. BACHMAN:—This subject has had very careful consideration. It was before the Standards Committee for consideration last January, and as a result of the discussion at that time it was referred back to the Division in cooperation with the committee of the American Society of Mechanical Engineers, and much very careful work was done.

(33) *Roller Transmission Chain Sprockets*

The Joint Committee has not completed its final recommendation for sprocket tooth forms in connection with standard cutters, as it wishes to give further consideration to both American and British practice. The Roller Chain Division does, however, recommend the adoption of the following sprocket dimensions as S. A. E. Standard to unify practice with regard to sprocket widths, clearances and transverse sections.



R (Min) = 0.43 P

P—Pitch	T—Sprocket Width	C	E	Lower Limits Bottom Diam. Sprockets	Clearance
⅜	0.227±0.004	0.113	1/64	0.004	0.023
½	0.284±0.005	0.150	1/64	0.006	0.028
⅝	0.343±0.006	0.1875	1/64	0.007	0.032
¾	0.459±0.007	0.225	1/32	0.009	0.041
1	0.575±0.008	0.300	1/16	0.012	0.050
1¼	0.692±0.010	0.375	1/32	0.015	0.058
1½	0.924±0.012	0.450	1/16	0.018	0.076
1¾	1.040±0.013	0.525	1/32	0.021	0.085
2	1.156±0.015	0.600	¼	0.024	0.094
2½	1.389±0.017	0.750	1/16	0.030	0.115
3	1.738±0.021	0.900	⅜	0.036	0.137
4	2.319±0.027	1.200	½	0.048	0.181
5	2.784±0.032	1.500	⅝	0.060	0.216
Formulas	T=0.93W—0.006 Tolerances = ±(0.001W+0.002)	0.3P	P/8	0.012P	0.07W+0.006)

SPRINGS DIVISION

(34) *Eye Bushings and Bolt Tolerances*

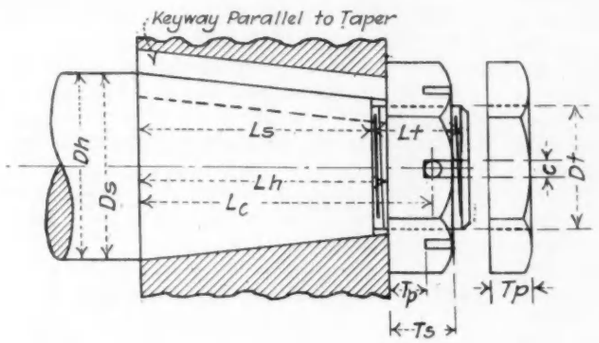
As the present S. A. E. Recommended Practice for Eye Bushings and Bolt Tolerances, page 49d, S. A. E. Handbook, Vol. I, does not specify the thickness of the bushing wall, it is recommended by the Springs Division that the Recommended Practice be extended to specify that the nominal wall thickness of spring-eye bushings shall be ⅛ in. for all sizes of bushings. This recommendation is based on the fact that the ⅛-in. wall thickness is widely used, and it is considered that bushings of less than ⅛-in. thickness would be unsatisfactory because of difficulties which would be experienced in pressing them in.

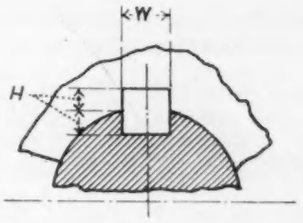
SHAFT FITTINGS DIVISION

(35) *Taper Fittings with Plain or Slotted Nuts*

The present specification printed on page 7c, S. A. E. Handbook, Vol. I, was adopted by the Society in June, 1914, and in several features does not conform to accepted engineering practice. Revisions have been made in nut dimensions, keyway dimensions, cotter-pin hole location and other details affecting the threaded portion of the shaft-end. The recommended revision provides for U. S. Standard nut dimensions throughout with the exception of the thread pitches which are S. A. E. Standard. This insures the use of standard wrenches and facilitates purchase of stock.

The Shaft Fittings Division recommends that the present S. A. E. Standard for Taper Fittings with Plain or





DIMENSIONS FOR TAPER FITTINGS WITH PLAIN OR SLOTTED NUTS

Nom. Diam.	Diam. of Shaft Ds max	Diam. of Shaft Ds min	Diam. of Hole Dh max	Diam. of Hole Dh min	Lc	Ls	Lh	Lt	Dt	Thds. per In.	Ts	Tp	Short Diam. of Nut	W max	W min	H max	H min	Square Key max	Square Key min	C
#10	0.250	0.249	0.248	0.247	9/16	5/16	3/8	5/16	#10	40	7/32	9/64	5/16	0.0625	0.0615	0.0342	0.0327	0.0635	0.0630	9/64
3/8	0.375	0.374	0.373	0.372	47/64	7/16	1/2	23/64	5/16	32	17/64	5/16	1/2	0.0937	0.0927	0.0499	0.0484	0.0947	0.0942	9/64
1/2	0.500	0.499	0.498	0.497	63/64	11/16	3/4	23/64	9/16	32	17/64	5/16	1/2	0.1250	0.1240	0.0655	0.0640	0.1260	0.1255	9/64
5/8	0.625	0.624	0.623	0.622	1 3/32	11/16	3/4	17/32	1/2	28	7/16	1/4	3/4	0.1562	0.1552	0.0811	0.0796	0.1572	0.1567	1/8
3/4	0.750	0.749	0.748	0.747	1 11/32	15/16	1	17/32	1/2	28	7/16	1/4	3/4	0.1875	0.1865	0.0968	0.0953	0.1885	0 1880	1/8
7/8	0.875	0.874	0.873	0.872	1 31/32	1 1/8	1 1/4	1 1/16	5/8	24	1/2	5/16	15/16	0.2500	0.2490	0.1280	0.1265	0.2510	0.2505	5/32
1	1.001	0.999	0.997	0.995	1 15/16	1 3/8	1 1/2	1 1/16	3/4	20	1/2	5/16	1 1/16	0.2500	0.2490	0.1280	0.1265	0.2510	0.2505	5/32
1 1/8	1.126	1.124	1.122	1.120	1 15/16	1 3/8	1 1/2	1 1/16	7/8	20	1/2	5/16	1 1/8	0 3125	0.3115	0.1615	0.1590	0.3140	0.3130	5/32
1 1/4	1.251	1.249	1.247	1.245	1 15/16	1 3/8	1 1/2	1 1/16	1	20	1/2	5/16	1 3/16	0.3125	0.3115	0.1615	0.1590	0.3140	0.3130	5/32
1 3/8	1.376	1.374	1.372	1.370	2 7/16	1 3/8	2	1 1/16	1	20	1/2	5/16	1 3/16	0.3750	0.3740	0.1930	0.1905	0.3765	0.3755	5/32
1 1/2	1.501	1.499	1.497	1.495	2 7/16	1 3/8	2	1 1/16	1	20	1/2	5/16	1 3/16	0.3750	0.3740	0.1930	0.1905	0.3765	0.3755	5/32
1 3/4	1.751	1.749	1.747	1.745	2 13/16	2 1/8	2 1/4	1 5/16	1 1/2	18	5/8	5/16	2 5/16	0.4375	0.4365	0.2242	0.2217	0.4390	0.4380	7/32
2	2.001	1.999	1.997	1.995	3 5/16	2 3/8	3	1 5/16	1 1/4	18	5/8	5/16	2 5/16	0.5000	0.4990	0.2555	0.2530	0.5015	0.5005	7/32
2 1/4	2.252	2.248	2.245	2.242	3 5/16	2 3/8	3	1 5/16	1 1/4	18	5/8	5/16	2 5/8	0.5625	0.5610	0.2962	0.2912	0.5645	0.5630	7/32
2 1/2	2.502	2.498	2.495	2.492	4 5/32	3 1/8	3 1/2	1 1/4	2	16	1	3/8	3 1/8	0.6250	0.6235	0.3275	0.3225	0.6270	0.6255	7/32
2 3/4	2.752	2.748	2.745	2.742	4 5/32	3 1/8	3 1/2	1 1/4	2	16	1	3/8	3 1/8	0.6875	0.6860	0.3587	0.3537	0 6895	0.6880	7/32
3	3.002	2.998	2.995	2.992	4 25/32	3 1/8	4	1 1/4	2	16	1	3/8	3 1/8	0.7500	0.7485	0.3900	0.3850	0.7520	0.7505	7/32
3 1/2	3.502	3.498	3.495	3.492	5 7/16	4 3/8	4 1/2	1 3/8	2 1/2	16	1 1/8	3/4	3 7/8	0.8750	0.8735	0.4525	0.4475	0.8770	0.8755	9/32
4	4.002	3.998	3.995	3.992	6 7/16	5 3/8	5 1/2	1 3/8	2 1/2	16	1 1/8	3/4	3 7/8	1.0000	0.9985	0.5150	0.5100	1.0020	1.0005	9/32

Dimensions in inches.

Tolerance on taper per foot = ±0.005 inch.

Slotted Nuts be revised to conform to the dimensions given in the accompanying table, including a tolerance of ± 0.005 in. which has been placed on the taper per foot as a guide in production.

THE DISCUSSION

CHAIRMAN B. B. BACHMAN:—This matter was also referred back to the Division at the meeting last winter. It has had much attention on the part of the Division and by Mr. Spicer. The two drawings are full-sized layouts made from the dimensions as listed in the table. It will be noticed that the nut proportions are brought down to more consistent ratios, particularly on these smaller sizes. Also that the location of the cotter-pin hole is more consistent than in the former table.

E. H. EHRMAN:—In the larger nut sizes is it the intention to follow U. S. Standard nut sizes?

C. W. SPICER:—Yes.

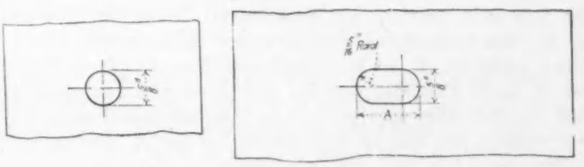
CHAIRMAN BACHMAN:—What is the authority to which the dimensions should conform?

MR. EHRMAN:—The best authority that I know of is a pamphlet published by the Navy Department that gives the U. S. Standard, which was promulgated in 1868. The Government also has a bulletin issued in 1880 giving these dimensions.

TIRE AND RIM DIVISION

(36) *Automobile Rim Valve Holes*

The Tire and Rim Division recommends that the present S. A. E. Standard for Automobile Rim Valve Holes, page 8xf, S. A. E. Handbook, Vol. I, be extended to include the dimensions for the 5, 8 and 10-in. tire rims and that certain lengths in the present Standard be increased. The present S. A. E. Standard revised and extended as recommended by the Division is given in the accompanying table:



Rim Size	3½	4	4½	5	6	7	8	10
A (Min.)	5/8	5/8	5/8	1 13/16	2 1/16	2 5/8	3 1/4	4 1/4

(37) *Felloe-Band Tolerances*

Owing to variations in the thickness of commercial tapes, with the resulting inaccuracy of wheel measurements, it is recommended that approved standard tapes be used for measuring felloe-band circumferences, of which one set is intended for truck and one for passenger-car wheels.

The Division therefore recommends that the present S. A. E. Standard for Allowable Tolerances in Felloe

Bands, page 8a, S. A. E. Handbook, Vol. I, be extended to include the following note:

> It is recommended that all measurements of truck and passenger-car wheel circumferences be made with approved standard wheel tapes furnished by the Tire and Rim Association.

(38) *Deflection and Set Test of Automobile Pneumatic Tire Rims*

The present S. A. E. Standard for Deflection and Set Test of Automobile Pneumatic Tire Rims, page 8f, S. A. E. Handbook, Vol. I, specified the pressure, deflection and permanent set for 3½, 4, 4½, 6 and 7-in. rims only. The Tire and Rim Division now recommends the pressure, deflection and permanent set for the 5, 8 and 10-in. rims. The present S. A. E. Standard extended to include the Division's recommendation follows:

PNEUMATIC TIRE RIM TESTS

Rim Size Nominal, In.	Maximum Pressure, Lb. Per Sq. In.	Maximum Deflection, In.	Total Permanent Set, In.
3½	140	0.06	0.02
4	160	0.07	0.03
4½	180	0.10	0.06
5	190	0.12	0.06
6	200	0.15	0.06
7	225	0.15	0.06
8	250	0.15	0.06
10	250	0.15	0.06

The deflection should be measured from a fixed inflation load of 25 lb. per sq. in. for 3½, 4 and 4½-in. sections, and 50 lb. per sq. in. for 5-in. and larger sections up to the maximum pressures given.

(39) *Motorcycle Rim Sections*

Circularization of the motorcycle industry last year indicated that standard current practice includes only tire sizes which are mounted on the CC rim. These tire sizes were adopted by the Society last winter and in order that the rim specification shall be in conformity with this list of tire sizes the Tire and Rim Division recommends that the BB rim section be withdrawn from the present S. A. E. Recommended Practice for Motorcycle Rim Sections, page 8k, S. A. E. Handbook, Vol. I. It is the opinion of both the Motorcycle and Tire and Rim Divisions that the BB rim section can be reestablished as a Standard should the use in the future of light weight motorcycles carrying the BB rim become general enough to warrant its inclusion in the Standard.

(40) *Carrying Capacity of Solid Tires*

CARRYING CAPACITY OF SOLID TIRES

Solid Tire Width, In.	36-in. Diameter or Less	40-in. Diameter
3	1000	....
3½	1300	....
4	1700	....
5	2500	3000
6	3500	4000
7	4500	5000
8	5500	6000
10	7500	8000
12	....	10000
14	....	12000

The present S. A. E. Standard for Carrying Capacity of Solid Tires, page 8bb, S. A. E. Handbook, Vol. I, has been criticized to the effect that at rated truck capacity an increase in the tire carrying capacities would be justified in practically all sizes and would conform to general practice.

The Division therefore recommends that the carrying capacities specified in the present S. A. E. Standard for Carrying Capacities of Solid Tires be revised to conform to capacities given in the table at the bottom of the preceding column.

(41) *Pneumatic Tires for Passenger Cars and Commercial Vehicles*

The Division recommends that the present S. A. E. Standard for Pneumatic Tires and Rims for Passenger Cars and Commercial Vehicles, page 8g, S. A. E. Handbook, Vol. I, be revised so as to eliminate the 42 x 9-in. tire and rim as regular equipment. This size tire is considered a special application as the oversize for the 40 x 8-in. on pneumatic-tired trucks and not as a regular size. It is also felt by the Division that the 44 x 10-in. is now well enough established to be included in the Standard as regular equipment.

The S. A. E. Standard revised as proposed is as follows:

NOMINAL TIRE AND RIM SIZES		OVERSIZE TIRE		TIRE-SEAT DIAMETER (RIM)		Type of Rim
In.	Mm.	In.	Mm.	In.	Mm.	
30x3½	90/585	31x4	105/585	23	585	Clincher
32x3½	90/635	33x4	105/635	25	635	Straight Side
32x4	105/610	33x4½	120/610	24	610	Straight Side
33x4	105/635	34x4½	120/635	25	635	Straight Side
33x4½	120/610	34x5	135/610	24	610	Straight Side
32x4½	120/585	33x5	135/585	23	585	Straight Side
34x4½	120/635	35x5	135/635	25	635	Straight Side
34x5	135/610	36x6	150/610	24	610	Straight Side
36x6	150/610	38x7	175/610	24	610	Straight Side
38x7	175/610	40x8	200/610	24	610	Straight Side
40x8	200/610	42x9	225/610	24	610	Straight Side
44x10	250/610			24	610	Straight Side

(42) *Rim Sections and Contours for Pneumatic Tires*

The Tire and Rim Division recommends that the present S. A. E. Standard for Rim Sections and Contours for Pneumatic Tires for Passenger Cars and Commercial Vehicles, page 8ha, S. A. E. Handbook, Vol. I, be revised in accordance with the dimensions submitted in the table on page 207. This table has been extended to include the dimensions for the 5-in. rim recently adopted and for the 10-in. rim which is recommended for adoption. The radius of the fillet for the 3½, 4 and 4½ straight-side rims has been increased from 3/32 to 3/16 in. owing to trouble which has been experienced with rims cracking at this point. Tolerances have also been placed upon the height of the 3½-in. rim.

These revisions have been adopted by the Tire and Rim Association and are in accordance with present practice.

There was considerable discussion in the Standards Committee Meeting relative to establishing in the Standard a single set of rim and felloe-band dimensions to provide for interchangeability of the 36 x 6, 38 x 7 and 40 x 8-in. pneumatic tire on a single rim, and also the interchangeability of this application on the wheel. This matter is to receive early consideration by the Tire and Rim Division and representatives of other automotive industries who are interested in this matter.

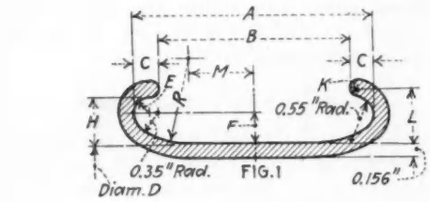


FIG. 1

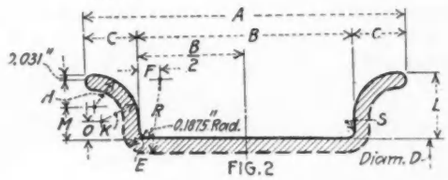


FIG. 2

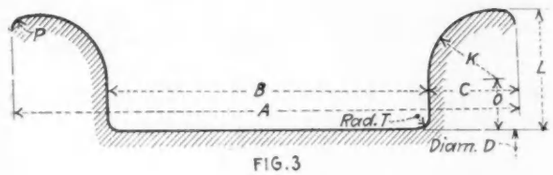


FIG. 3

ject, because we have been asked many times if we could do anything toward bringing about the interchangeability of the 6, 7, and 8-in. sizes so that the same rim would take any one of those. I have corresponded with several of the truck builders who express the same thought. Various suggestions are made as to the ways and means and the actual manner in which such an arrangement could be accomplished.

E. E. WEMP:—The matter of interchangeability of the 6, 7, and 8-in. tires is, I believe, very important, and it was brought up at the last meeting of the Truck Standards Division in Cleveland. When the governing dimensions are analyzed to a finality, there is so little difference in them that it seems quite practical to combine the dimensions so as to make one standard rim that will take all three of the tires.

As a means of bringing the subject to the attention of the Standards Committee, not with the idea of its being final, I had a sketch made up of a tire base, using a felloe-band width of 4 in. as being possibly a practical mean width that could be used on all the sizes. Taking the difference between the narrowest one, the 6-in., and the widest one, the 8-in., the mean dimension would be 3 15/16 in. I set this dimension as 4 in., this being an even dimension and favoring, possibly, the larger tire slightly on account of the larger amount of overhang which might be detrimental on the larger size.

This is a matter in which every truck builder is interested. These three tire sizes are the ones that are more commonly used, and with present load distribution it is almost impossible to put on the same-size tire, front and rear. I think it is an advantage to the manufacturer to put a rim on the rear wheel on which the next oversize tire can be placed without using the oversize tire on the smaller-size rim as standard equipment.

PNEUMATIC TIRE RIM SECTIONS AND CONTOURS

Fig. No.	Nominal Tire and Rim Size	Rim Diam. (Tire Seat)	Rim Circum. (Tire Seat) ±0.046	A	B		C	R	E	F	H	K	L		M	O	P	S	T
					Nom.	Tol.							Nom.	Tol.					
1	30x3½	23	72.257	2.600	2.050	±0.046	0.275*	0.910	0.1400	0.3400	0.50	0.0780	0.5780	±0.008	0.680	.....	.....	....	.....
	32x3½	25	78.540	3.432	2.312	±0.046	0.560	0.840	0.1875	0.2500	0.32	0.5100	0.6870	+0.0125	0.367	0.1990	.....	0.0625	.....
2	32x4	24	75.398																
	33x4	25	78.540	3.888	2.688	±0.046	0.600	0.840	0.1875	0.2500	0.34	0.5600	0.7800	−0.0075	0.440	0.2450	.....	0.0625	.....
	34x4	26	81.681																
	32x4½	23	72.257																
2	33x4½	24	75.398	4.380	3.120	±0.046	0.630	0.840	0.1875	0.3125	0.38	0.6150	0.8750	−0.0075	0.495	0.3030	.....	0.0625	.....
	34x4½	25	78.540																
	34x5	24	75.398	5.310	3.750	±0.047	0.780	.....	.....	.....	....	0.6250	1.0625	±0.024	....	0.4375	0.0940	....	0.2500
	36x6	24	75.398	6.330	4.330	±0.047	1.000	.....	.....	.....	....	0.7187	1.2656	±0.024	....	0.5469	0.1400	....	0.2500
3	38x7	24	75.398	7.000	5.000	±0.047	1.000	.....	.....	.....	....	0.7187	1.2656	±0.024	....	0.5469	0.1400	....	0.2500
	40x8	24	75.398	8.500	6.000	±0.063	1.250	.....	.....	.....	....	0.8750	1.5000	±0.031	....	0.6250	0.1500	....	0.3125
	44x10	24	75.398	10.330	7.330	±0.063	1.500	.....	.....	.....	....	1.2500	2.0000	±0.031	....	0.7500	0.1875	....	0.3125

All dimensions are in inches.
*Tolerances of +0.016, −0.008 in. apply to this dimension.

THE DISCUSSION

S. P. THACHER:—The radius of the fillet on the straight-side rim has been increased. The reason is that steel is becoming a rather variable quantity and the rim manufacturers asked for the increased radius because of rims becoming cracked at that point. The Tire and Rim Association approved the larger radius as an emergency measure. Since then it has watched the situation closely and the change does not seem to have developed any difficulties. It is believed to be perfectly safe to write it into the S. A. E. Standards because it simplifies the rim manufacturers' problem and does not hurt the tires.

G. L. LAVERY:—The Automobile Metal Wheel Association and the metal wheel manufacturers would like to have action taken toward establishing one rim size and contours to take the 36 by 6, 38 by 7, and 40 by 8-in. pneumatic tires. This will permit of mounting the three tires on a single-size rim and will make these applications entirely interchangeable on the wheels.

F. W. DAVIS:—I would like to add a word on that subject, because we have been asked many times if we could do anything toward bringing about the interchangeability of the 6, 7, and 8-in. sizes so that the same rim would take any one of those. I have corresponded with several of the truck builders who express the same thought. Various suggestions are made as to the ways and means and the actual manner in which such an arrangement could be accomplished.

E. E. WEMP:—The matter of interchangeability of the 6, 7, and 8-in. tires is, I believe, very important, and it was brought up at the last meeting of the Truck Standards Division in Cleveland. When the governing dimensions are analyzed to a finality, there is so little difference in them that it seems quite practical to combine the dimensions so as to make one standard rim that will take all three of the tires.

As a means of bringing the subject to the attention of the Standards Committee, not with the idea of its being final, I had a sketch made up of a tire base, using a felloe-band width of 4 in. as being possibly a practical mean width that could be used on all the sizes. Taking the difference between the narrowest one, the 6-in., and the widest one, the 8-in., the mean dimension would be 3 15/16 in. I set this dimension as 4 in., this being an even dimension and favoring, possibly, the larger tire slightly on account of the larger amount of overhang which might be detrimental on the larger size.

This is a matter in which every truck builder is interested. These three tire sizes are the ones that are more commonly used, and with present load distribution it is almost impossible to put on the same-size tire, front and rear. I think it is an advantage to the manufacturer to put a rim on the rear wheel on which the next oversize tire can be placed without using the oversize tire on the smaller-size rim as standard equipment.

MR. THACHER:—The Tire and Rim Division did not feel that we had gotten to the point where we could consider the subject finally. The recommendation made is the best that we can make at this time.

H. M. CRANE:—Is the 4-in. width sufficient to satisfy the requirements of the wooden wheel-makers on wooden felloes? As far as the demountable rim is concerned, there is no engineering reason why the 4-in. width should not do for practically any size. It is simply a question of designing the demountable rim strong enough to carry the overhang which might affect the wooden wheel.

MR. WEMP:—The oversize tire is very commonly placed on the smaller size rim having a smaller felloe width.

C. C. CARLTON:—We are heartily in favor of the universal felloe-band that would take these three sizes, if it can be worked out. We have had some correspondence with the manufacturers and designers of these bands in trying to attain that end. They claim that a mean width would be too wide for the narrowest, or 6-in., size and too narrow for the largest, or 8-in., size. Inasmuch as these three sizes are now in universal use by all rim and tire manufacturers, it would be a mistake, it seems to me, not to adopt them even though they could be changed within the next six months, because of the fact that they are such a perfect standard and are considered so by all tire and rim manufacturers at the present time.

In reply to Mr. Crane as to whether the width of the wooden rim would be sufficient, if you made 4 in. the mean width, I think that could be worked out well with a wood wheel. I believe that all of the wood-wheel manufacturers would be perfectly willing to see a 4-in. width adopted if it could be adopted as a universal width for all these sizes.

MR. DAVIS:—It would seem that approving the recommendation of the Division at this meeting will only put off still further the possible adoption of some standardization which will give us interchangeability. It seems to me that right now is the time to consider this, not to the point of suggesting some revised figures or some other schedule of rim dimensions, but to refer the subject back for consideration. In that way we will have a good intention before us, and at the next Standards Committee Meeting, or at the next meeting of the Tire and Rim Division, an active effort will be made to get that subject worked out. The thought was not that we would attempt to arrive at one dimension necessarily, if objections were found to that course, but it might be possible to work out some sort of an adapter ring or other arrangement whereby there could be a certain amount of interchangeability.

The owners and operators are objecting strenuously to the necessity for carrying two inflated tires weighing some hundreds of pounds. They do not know where to put them, and they use them possibly once a year. If we can offer them any solution, temporary or permanent, which will enable them to carry one inflated spare tire on a special rim, if necessary, which would be adapted to the front and rear wheels they would be glad to do it. It seems to me that now is the time for some decisive action which will bring about the desired interchangeability, either by adopting an interchangeable rim, adapter rings or some other method.

CHAIRMAN B. B. BACHMAN:—The point to be recognized is that we have a proposition that is very difficult of solution. It is not a question of adopting something new today, as the proposals in the main are already adopted by the Society. It is not within the power of this Committee to take action undoing existing standards of work, except upon the recommendation of a Division. If this report is rejected we simply revert to what is now printed in the Handbook. The mere detail of the fact that this happens to be included in this report is not pertinent. A very important matter has been brought up now and should be considered without any delay.

MR. DAVIS:—I think, under the circumstances, the motion to adopt the report had better be accepted. I also think that it is the consensus of opinion of those present that the suggestion in this connection should receive the earliest possible consideration by the Tire and Rim Division.

MR. LAVERY:—I move that the Council be requested to assign to the Tire and Rim Division the matter of considering the possibility of a single set of rim and base contour dimensions that will secure interchangeability through a universal standard for the 36 by 6, 38 by 7, and 40 by 8-in. pneumatic rim sizes.

(43) *Pneumatic Tire Felloe-Bands*

An agreement has been reached among rim manufacturers for the dimensions of the 5, 6, 7, 8 and 10-in. pneumatic truck tire felloe-bands, which are given in the accompanying tables. This proposal has been accepted by the Tire and Rim Association and the Tire and Rim Division recommends it for adoption as S. A. E. Standard.

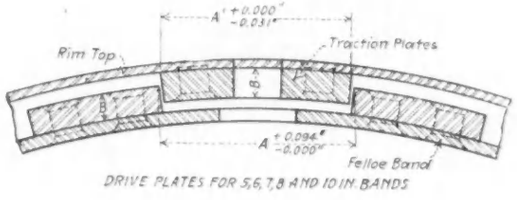


FIG. 4—TRACTION-PLATE DIMENSION

Rim Size	A	B	Width of Traction Plates
5	2½	⅜	1½
6	2½	⅜	2
7	2½	⅜	2½
8	2½	⅜	2⅝
10	3	⅝	3¼

Note. — Information recently received indicates that this report as approved by the Standards Committee should be modified as follows:

Dimensions *A'* on the drawing are the same as *A* in the table and the tolerance on *A'* should be plus 0.000 in., minus 0.031 in. The width of traction plate for the 10-in. rim should be 3⅛ in. In marking letter ballots members should indicate whether they approve the report with these corrections included.

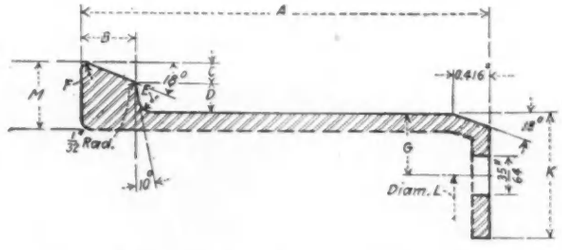


FIG. 1—5, 6, 7 AND 8-IN. FELLOE BANDS

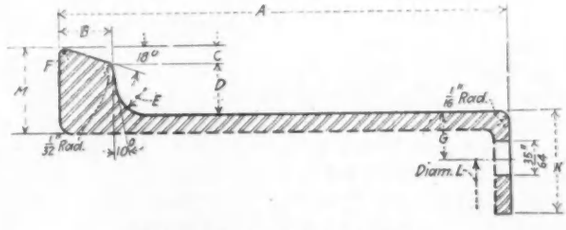


FIG. 2—10-IN. FELLOE BAND

PNEUMATIC TIRE FELLOE-BAND DIMENSIONS

Fig. No.	Rim Size	A	B	C	D	E	F	G	K	M	L Bolt Circle Diameter	Bolts (Fig. 3) Number	Bolts (Fig. 3) Length
1	5	2 31/32	11/32	0.153	1/4	1/8	1/16	0.656	1 3/16	0.558	21.375	8	3 3/4
1	6	3 1/16	11/32	0.183	11/64	1/8	1/16	0.750	1 3/16	0.636	21.125	10	4 1/2
1	7	4 3/32	11/32	0.183	11/64	1/8	1/16	0.750	1 3/16	0.636	21.125	10	5 1/4
1	8	4 1/16	11/32	0.183	11/64	1/8	1/16	0.625	1 3/16	0.729	21.125	10	5 1/2
2	10	5 1/16	5/8	0.203	0.620	3/8	1/16	0.563	1 1/4	1.042	20.625	10	6 1/2

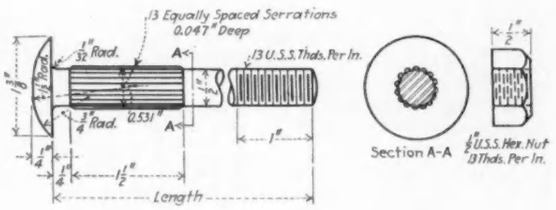


FIG. 3—BOLT AND NUT

Note.—Information recently received indicates that this report as approved by the Standards Committee should be modified as follows:

Dimensions *G* in the table apply to felloe-bands for metal wheels. The corresponding band dimensions for the 6, 7 and 8-in. rims for wood wheels should be 0.688 in. The felloe-band bolt circle diameter *L* for the 6 and 7-in. rims on wood wheels should be 21¼ and 21 in. for the 8-in. size.

In marking letter ballots members should indicate they approve the report with these corrections included.

(44) *Carrying Capacities and Inflation Pressures for Motorcycle Tires*

The revised S. A. E. Standard for motorcycle tire sizes includes 3 and 3½-in. sections only, and it is therefore recommended by the Division that the carrying capacity and inflation pressure for the 2¼-in. motorcycle tire printed on page 8h, S. A. E. Handbook, Vol. I, be omitted.

TRACTOR DIVISION

(45) *Tractor Drawbar and Belt-Power Ratings*

The establishment of a definite method of rating tractor drawbar and belt power has been considered at length by the Tractor Division and the Standards Committee. Formulas for Nominal Engine Horsepower and Tractor Drawbar Rating were developed and reported, but not adopted as S. A. E. Standards because they are considered of value for commercial and legislation purposes but not for engineering work. These formulas are, however, printed as general information on page 20b, S. A. E. Handbook, Vol. I.

In view of the decision reached by the Standards Committee last January, and the publication of the formulas referred to above, the Division recommends that the S. A. E. Standards for Tractor Drawbar Rating and Tractor Belt-Power Rating on page 55, S. A. E. Handbook, Vol. I, be withdrawn.

(46) *Steels for Tractors*

This specification was adopted at a time when it was felt that only a limited use of the S. A. E. Steels could be recommended. Inasmuch as the Tractor Division has approved all of the existing S. A. E. steel specifications for tractor practice, it is recommended that the present S. A. E. Recommended Practice for S. A. E. Steels for Tractors, page 55xa, S. A. E. Handbook, Vol. I, be withdrawn.

(47) *Tractor Screws and Bolts*

As the present S. A. E. Standard for Screws and Bolts, page 4, S. A. E. Handbook, Vol. I, is in general use in the tractor industry, it is recommended that the S. A. E. Recommended Practice for Tractor Screws and Bolts, page 55xa, S. A. E. Handbook, Vol. I, which specifies that U. S. Standard as well as S. A. E. Standard screws shall be used in a limited number of sizes for tractor practice, be withdrawn.

(48) *Height of Tractor Drawbars*

The present S. A. E. Standard for Height of Tractor Drawbar, page 55, S. A. E. Handbook, Vol. I, specifies a height of 17 in. for plowing and other work. With the type of tractor where the wheel runs in the furrow the hitch is dropped to a height of about 15 in., which is considered desirable for plowing at the average depth, but when the tractor wheel runs on unbroken ground the hitch is too high. As about 50 per cent of the two, three and four-plow tractors manufactured at the present time are of this type, it is the opinion of the Tractor Division that the present Standard should be revised. The National Implement & Vehicle Association in cooperation with the Tractor Division has also given this subject considerable attention, made extensive tests, and has concluded that the fixed height of 17 in. is not entirely adequate.

The Division therefore recommends that the present S. A. E. Standard be revised to read:

> The height of vertically fixed drawbars on tractors of capacities up to and including four plows shall be 15 in. when the tractor is on level ground.
>
> The height of vertically adjustable drawbars on tractors of all capacities shall be from 13 to 18 in. when the tractor is on level ground.

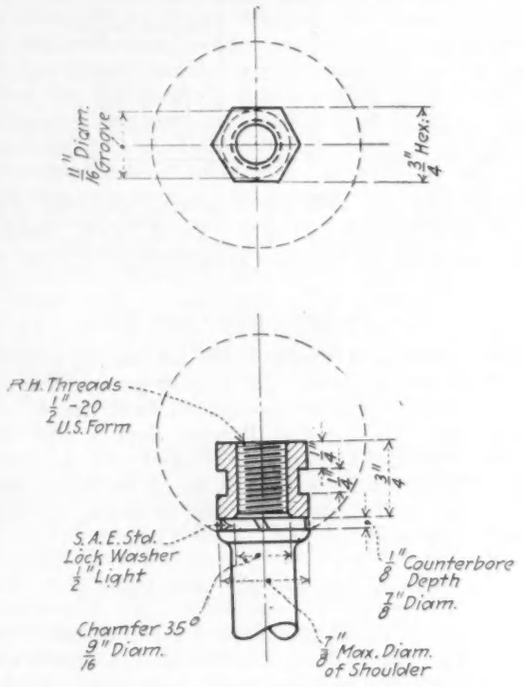
If this revision is approved by the Society the Standard will become an Agricultural Equipment Standard as the National Implement & Vehicle Association has definitely adopted these drawbar heights.

THE DISCUSSION

O. B. ZIMMERMAN:—Some time ago the fixed height of 17 in. was adopted as the standard height of tractor drawbars. This is not now in conformity with good practice, and after considerable discussion and study by the Tractor Division of the Society in cooperation with the National Implement & Vehicle Association, it is recommended that the 17-in. standard be revised as recommended in the report.

Transmission Division

(49) *Control-Lever Ball-Handle Inserts*



Control-Lever Ball-Handle Insert Dimension

Many of the transmission and molded material manufacturers indicated their opinion that there is a needless variety of designs and thread sizes and pitches now in use and that a suitable standard is desirable. To secure interchangeability of the ball-handles on control-levers of different makes and to lessen the cost of production, the Division recommends the adoption of the accompanying proposal as S. A. E. Standard. This will permit the use of one size of stock, cheaper and uniform screw-machine tooling and set up, and uniformity in ball-molding dies. As strength is not the important factor, the proposal is considered suitable for use on the several types of automotive vehicles.

Attendance at Meeting

The members of the Standards Committee and the Society and the guests in attendance were:

Standards Committee Members

J. J. Aull
B. B. Bachman
R. J. Broege
H. C. Buffington
R. S. Burnett
E. L. Clark
C. F. Clarkson
H. M. Crane
F. W. Davis
L. R. Davis
E. A. DeWaters
E. H. Ehrman
W. S. Haggott
W. S. Harley
Capt. F. C. Hecox
Herbert S. Jandus
E. A. Johnston
W. C. Keys
George L. Lavery
A. D. T. Libby
W. T. Norton, Jr.
H. S. Pierce
A. W. Scarratt
H. C. Snow
C. W. Spicer
Howard J. Stagg
W. R. Strickland
S. P. Thacher
Joseph VanBlerck
W. G. Wall
S. O. White
F. G. Whittington

Guests

C. R. Alling
Vincent G. Apple
George M. Bartlett
David Beecroft
George T. Briggs
A. P. Brush
W. A. Brush
L. J. Campbell
L. L. Campbell
H. R. Cobleigh
H. R. Corse
R. M. Critchfield
P. J. Dasey
H. M. Denyes
A. V. Farr
E. H. Fitch
James D. Flood
Mortimer Frankel
W. R. Gage
E. S. Gorrell
A. C. Hargreaves
C. E. Hawke
P. M. Heldt
Ferdinand Jehle
Clyde Jennings
M. S. Kerr
G. A. Kraus
D. W. Lathrop
N. Lazarnick
H. A. Little
F. B. Lounsberry
John McGeorge
Albert G. Metz
F. E. Moskovics
Cornelius T. Myers
O. W. Nacker
Harry W. Parsons
W. S. Peper
N. B. Pope
Warwick Ray
Fred D. Rice
J. Edward Schipper
H. Schlachter
L. F. Seaton
H. W. Slauson
Lon R. Smith
Mark A. Smith
W. K. Swift
J. G. Utz
J. G. Vincent
L. V. West
C. E. Wilson
W. C. Wilson
A. M. Wolf
O. B. Zimmerman

ENGINEER'S PROBLEMS INVOLVING MEN

ALMOST everyone who is familiar with the engineering courses offered at the average technical school and university in our country agrees that our student engineers are being taught technical subjects that fit them to solve problems where materials, machines and forces of nature are involved, but that practically nothing is taught them to assist in solving the problems involving men. The importance of this phase of engineering education was recently made apparent by the result of an investigation conducted by the Carnegie Foundation for the Advancement of Teaching. Starting in the year 1915, Dr. Mann sent out questionnaires to leading engineers all over our country asking them to state their views concerning the elements that make for the professional success of the engineer. A statistical summary of over 6000 returns is presented in the accompanying table.

	Per cent
Character	24.0
Judgment	19.5
Efficiency	16.5
Understanding of Men	15.0
Knowledge of Fundamentals	15.0
Technique	10.0

This being true, the colleges cannot limit themselves to the teaching of those subjects which make for perfection in professional knowledge and technique. They must also consider the development of judgment, understanding of men, efficiency and character. Many persons interested in safety think that a presentation of the principles of accident prevention to student engineers will assist materially in developing a proper understanding of men, and at the same time make a valuable addition to the student's engineering knowledge.—W. . . Keefer, secretary, education committee, National Safety Council.

THE RUBBER COMPANIES AND THE AUTOMOBILE INDUSTRY

THE remarkable growth of the automobile industry in the last four years and especially since the close of the war is reflected in the expanding production and growing prosperity of the rubber companies. The total sales of rubber tires in the United States this year will exceed $1,000,000,000. In 1916 they were less than $500,000,000. In the current year approximately 40,000,000 tires will be produced, compared with 18,500,000 in 1916. In addition, millions of dollars worth of rubber footwear, clothing and mechanical goods will be manufactured.—*Wall Street Journal.*

STANDARDIZATION

AS the advantages of standardization become evident from its results on the industries which have adopted standards, other industries are taking up standardization work to facilitate progress and development along efficient lines. With regard to the essentiality of intelligent standardization, few of intimate knowledge of the automotive industry need information or assurance. Standardization has been the great development in the progress of the automotive field. It has enabled the automotive manufacturer to meet market conditions rapidly and effectively. It has made mass production possible.

As applied to the building industry, that is the erection and equipment of modern structures, standardization is as essential to successful results as is the standardization of time, weight and measures. Attainable results are the elimination of a tremendous amount of individual effort, time and expense in the preparation of specifications and detail drafting and a saving of lost motion and waste in the production and application of materials and parts. Production can be kept well in advance of demand and needless variation in types, sizes, patterns, and finishes, together with unnecessary carrying of large stocks, is greatly reduced. By standardization I do not mean duplication in the design of houses. Why not standardize household fixtures and the height and size of doors and windows? Such standardization will increase production and decrease cost and be one step in the solution of the present world-wide housing problem.

The work of standardization committees is unselfish and warrants the services of men who will rise to the occasion and work hard for the good of all. The work must be thorough and of the highest class or the results of it will be short-lived. The standards committee should comprise a large number of experienced men so that the work may be upon a broad basis and have applied all of the checks that are so necessary in all great undertakings. It is a sad fact that selfishness has always interfered, and probably will always interfere, with the evolution and final adoption of standards. The old-fashioned practice of wrapping a process up in mystery or surrounding it with a halo of secrecy still persists. The war, however, has shown the futility of carrying on this practice, because the free exchange of information by competitive organizations helped to develop new and better materials, methods and processes which every one benefited by. The wider use of the best adopted materials improves working and living conditions, insures a high, uniform degree of safety and efficiency during and after construction.

In standardization work, as in all other work involving the effective progress of the world's affairs, the needs or desires of all, not the whims or caprices of some, are the great desiderata. Needless variation in type or pattern causes useless expense and many difficulties in merchandizing, fills shelves and stores with surplus stock, and contributes to the high cost of living.

A standard is that which one naturally turns to as being the best and most logical material, or construction, to use, and is the intelligent result of experience.

Until recently there has not been in this country a body having control of engineering standardization in general and seeking to correlate the efforts of the different groups working in that line. That there is need for such a body is obvious. The chief reason is that each of the standards committees standardizes not only the products of its particular industry, but also the raw material and semi-finished products which are used by this industry and purchased from outside sources. Now, these same raw materials and semi-finished products are used also by other industries, and if each of the industries taking up standardization should formulate its own standards for such materials, standardization, instead of a blessing, would prove a curse. A case in point is that of steel. The Society of Automotive Engineers has standardized a great many steels used in the manufacture of automobiles and other automotive apparatus. It has assigned a number to each steel, given the required chemical composition, worked out suitable heat-treatments and made a beginning in tabulating the physical properties of these steels as affected by heat treatment. Now, steel is used by all or practically all of the engineering industries, and if any considerable number should attempt to draw up standard specifications without regard to what has already been done, it would lead to endless confusion. Even a change in the numbers which are used to designate certain grades of steel would be objectionable.

It is mainly because certain matters calling for standardization are of such wide import that there is need for a general standardization committee representing the entire engineering world. Such a committee has been formed from the membership of the five great engineering societies. The actual work of standardization, the creative work, as it were, must necessarily be done by men in very close touch with the particular industry or branch of industry to which the standards apply, but there is a promising field for the general organization in supervising the work of the different branches so as to avoid overlapping of effort. The American Engineering Standards Committee makes it possible to give an international status to American engineering standards and to cooperate with similar organizations in other countries. Similar organizations are now functioning in Great Britain, France, Switzerland, Holland and Canada. Through the new committee, the methods of arriving at engineering standards will be unified and simplified, and by cooperation the duplication of standardization work will be prevented. Standards will not be created without giving all interested an opportunity to participate. The "approval" of a standard by the American Engineering Standards Committee does not mean that the committee has itself worked over and approved each detail. It does signify, however, that the work has been carried out by a sectional committee adequately representing the industry concerned and sponsored by one or more bodies of ability, experience and standing, so that the result may stand for what is best in American engineering practice.

Any organization may request the committee to approve standards which it has formulated or to approve committees that it has appointed and by so doing becomes a sponsor society. Two or more organizations may act as joint sponsors. Approval of a standard is given when it is the substantially unanimous conclusion of a sectional committee made up of representatives of producers, consumers and general interests and so selected that all interests concerned have adequate representation.

It is understood that a standard must be referred to as that of the sponsor, using whatever title the sponsor has given it, followed by the statement, "Approved by the American Engineering Standards Committee." The approval may be given in one of three ways: "Recommended Practice," "Tentative Standard" or "American Standard."

In addition to its assistance in the selection of committees and certifying that their work has been done under proper conditions, the committee will act as a bureau of information regarding standardization. It will collect information regarding existing standards and as to the bodies that have formulated or adopted them. This will enable it properly to give the data to those who select a committee to formulate a new standard or revise an old one.—Joseph A. Anglada in *The Sabean.*

Book Reviews *for* S. A. E. Members

This section of THE JOURNAL contains notices of the technical books considered to be of interest to members of the Society. Such books will be described as soon as possible after their receipt, the purpose being to show the general nature of their contents and to give an estimate of their value.

THE A B C OF AVIATION. By Victor W. Pagé. Published by the Norman W. Henley Publishing Co., 2 West Forty-fifth street, New York City. Cloth, 5½ by 8½ in., 274 pages, 137 illustrations.

This book which was written with special reference to the requirements of some technical men who have taken up aviation is a complete practical treatise outlining clearly the elements of aeronautical engineering. Special attention has been paid to simplified explanations of the theory of flight, aerodynamics and the principles underlying the action of balloons and airplanes of all types. The text is supplemented by a number of specially prepared diagrams. The basic principles of aviation are described and the reader is told in simple language how a balloon or dirigible is made and why it floats in the air. The flight of an airplane is described and the different parts are illustrated and their functions described. The differences in the construction of various types of airplane are pointed out together with their advantages and disadvantages. Instructions which are based on a series of lectures given by the author at one of the Signal Corps aviation schools for lining up and adjusting airplanes are included. Some observations on flying which have been suggested by an experienced pilot are presented.

The book is divided into twelve chapters, and in the first the various aircraft types are illustrated and described. Lighter-than-air craft receive attention in the next chapter while early airplanes and the general design and construction of the aerofoils and the construction of the wings, fuselage, the powerplant and the propeller receive attention in the next four chapters. The principles governing the equilibrium and control of the airplane are brought out in Chapter IX, and instructions for uncrating, setting up and aligning the plane are given in the next chapter. Chapter XI deals with the inspection of the plane before flight, and the concluding chapter is a dictionary of the terms used in connection with aviation, all the definitions given having received the approval of the National Advisory Committee for Aeronautics. A comprehensive index completes the book.

ELEMENTS OF ACCOUNTS. By Charles F. Rittenhouse, C. P. A. Published by the McGraw-Hill Book Co., Inc., 239 West Thirty-ninth Street, New York City. Cloth, 6 by 9 in., 264 pages, numerous illustrations.

This book is designed to serve as a textbook where instruction is given in specialized fields of accounting such as for individuals, professional men and students. It is based upon the author's experience as an instructor and is the outgrowth of a book that was privately published about four years ago for use in his own classes. The book can be used as a textbook for a two years' course and will also be found of value to the general reader searching for information on the practical side of business and financial affairs, to professional men who desire to introduce more businesslike methods in the management of their affairs and to officials of institutions of various kinds for the same reason.

The first of the two parts into which the book is divided contains a discussion of the general principles of bookkeeping as applied to mercantile accounts while the second deals with the accounts of private individuals, professional men and students. The various types of account used are illustrated and described and short problems and exercises are included to supplement the text. Throughout the entire book and especially in the second half the method of presentation is simple and direct as the language has been kept free from technical terms. All of the methods suggested are practical and easy of adoption.

PUNCHES AND DIES. By Frank A. Stanley. Published by the McGraw-Hill Book Co., Inc., 239 West Thirty-ninth Street, New York City. Cloth, 5¾ by 9 in., 434 pages, 618 illustrations and 15 tables.

Certain definite information on the layout, construction and the use of punches and dies which has not been heretofore available as a whole is placed before die and tool makers and tool draftsmen in this book. Approximately 90 per cent of the material was expressly prepared for this volume and is published for the first time. Current articles recently published by the author in connection with his work as a member of the staff of the *American Machinist* and other contributors to the technical press provide the remainder. Some of the information is of a fundamental character but this the author deems necessary in order that all mechanics may secure a reasonably complete knowledge of the subject of press tools which are now being extended into so many lines of manufacture.

The book is divided into twenty chapters. Since it has become the practice to produce by some form of the stamping process more and more work that was formerly almost invariably manufactured from the solid bar, from forgings or from some other class of solid material, the extension of the increased fields for which the stamping press is used are described in the first chapter together with a brief classification and description of the various types of dies. In the next thirteen chapters the different dies are taken up in some detail, the text being supplemented by numerous illustrations of the dies themselves and typical examples of the work produced by each. Standards for punches and dies are discussed in chapter XV and in the next one rules for finding the size of blanks for shells and other drawn and formed work are presented. Laying out and making templets and dies are described in chapter XVII. The problem of locating the small holes which are often required in piercing dies and in progressive piercing and blanking tools with the degree of accuracy desired particularly where no special means in the way of a vernier-equipped drilling machine or other tool of similar purpose is available is discussed in chapter XVIII. Instructions on making a set of shaving dies are given in the next chapter with illustrations showing the important steps in the construction. The application of hardening principles to prevent the labor of the diemaker in the production of an accurate set of dies from being wasted by improper treatment of the work in the hardening process is discussed in the concluding chapter. A list of authorities referred to and a comprehensive index are included.

AUTOMOTIVE STARTING, LIGHTING AND IGNITION. By R. C. Fryer. Published by John Wiley & Sons, Inc., New York City. Cloth, 4¾ by 7⅜ in., 210 pages, numerous illustrations.

The primary purpose of this book is to form the basis of a classroom lecture course on starting, lighting and ignition for automotive apparatus. For that reason the information while of a general nature is nevertheless presented in a concise form, the object being to include all that is essential for the student. The real value of the book lies in the elimination of the need for the student to take pencil notes of the lectures. The way in which the author has intended the book to be used is as a means of giving the student the fundamental principles of the various subjects, this study being supplemented with demonstrations by the instructor with laboratory apparatus and diagrams on the blackboard.

The book is divided into two approximately equal parts, the first of which contains the text matter. The subjects of

magnetism, electricity, electro-magnetism and induction are briefly but thoroughly discussed and followed by a statement of their application to battery and magneto ignition. Generators, motors and storage batteries also receive attention, instructions for their care being added to the descriptive matter. Suggestions for locating trouble in the various circuits are presented, followed by a list giving the firing order and timing of the ignition systems of the leading makes of car. There is a series of lessons consisting of questions designed to test the student's knowledge of various pieces of ignition apparatus. The second section of the book is entirely given over to diagrams showing the various forms of electrical equipment used. The index if amplified somewhat would materially facilitate the finding of any desired subject or illustration.

PRACTICAL AVIATION FOR MILITARY AIRMEN. By Major J. Andrew White. Published by the Wireless Press, Inc., 25 Elm Street, New York City. Cloth, 6 by 9¼ in., 197 pages, 200 illustrations.

The volume which is designed as a textbook for intensive study by men preparing to become military aviators contains all the knowledge of the fundamentals required prior to actual flying and air combat. While this is the primary purpose of the book it can also be used for training commercial aviators since it contains a broader treatment of subjects not usually included in general aeronautic textbooks. In appearance the book differs materially from the commonly accepted textbook standards as it is made up of a series of condensed statements in which relative sizes and boldness of type are employed to give the proper valuation of the importance of the statements while the illustrations are arranged in close proximity to the text explanation so that it is unnecessary to turn the page to apply the material. Thus each page is practically a brief blackboard talk or illustrated lecture. Each of the chapters is preceded by a skeleton outline of the subject matter and followed by a review quiz designed to start a train of thought in the mind of the reader which will encourage him to turn back and refresh his memory on the text.

There are fifteen chapters, the first of which outlines the theory and principles of flight. Following this the elements of airplane design and the various parts of the plane are discussed. Instructions for the airman on flying and meteorology are presented in the next two chapters and the two concluding ones deal with the combat side of flying. An appendix which gives the nomenclature of aeronautical terms with their French equivalents and pronunciation completes the book.

INTERNAL-COMBUSTION ENGINE MANUAL. By Lieut. Commander F. W. Sterling, U. S. N. Published by R. Beresford, 605 F Street, Northwest, Washington. Cloth, 5½ by 9⅛ in., 168 pages, 93 illustrations.

This is the fourth edition of a work which was originally brought out eight years ago for use as a textbook for a short course on internal-combustion engines for the midshipmen at the Naval Academy. This revision has brought the book entirely uptodate. In its present form the manual is condensed and well-written and although intended primarily for students in the marine engine field can also be used as a textbook for courses such as are being offered by many of the universities in the country to train men in the handling of engines in aircraft work. For this reason, while it covers the theory and practice of internal-combustion engines and allied subjects it is fairly elementary in character, thermodynamics not being touched upon except in a very general way and the elaborate mathematical demonstrations and theories found in most textbooks being omitted.

The arrangement of the twelve chapters is the logical one; fuel, the element which governs the design and operation of the engine, is taken up first. The fuel, ignition, lubricating and cooling systems are then treated in considerable detail and a number of illustrations are used to amplify the text. The different methods of governing are described and the analysis of indicator cards and the application of information gained in this way to the securing of ideal operating conditions are touched upon as are also the troubles frequently encountered in operation and their remedies. The standard engines for the Navy submarine chasers, and the sleeve-valve and various other types are discussed. The chapter on the Diesel engine has been almost entirely rewritten and a new chapter on aircraft engines which is illustrated with views of the latest types has been added.

DESIGN AND CONSTRUCTION OF HEAT ENGINES. By William E. Ninde. Published by the McGraw-Hill Book Co., Inc., 239 West Thirty-ninth Street, New York City. Cloth, 6 by 9 in., 704 pages, 466 illustrations and 107 tables.

In preparing this book an endeavor has been made to supply in one volume the material most essential to a well-equipped, independent heat engine designer and to present it in the most convenient form for use in the classroom and for practical work. The author in preparing this book has drawn upon his notebooks on engine design covering his practice and observation for over twenty years, with the necessary revisions and additions to adapt the notes to his teaching work for the past ten years. Material from technical books and periodicals that has been needed to fill in the gaps in first-hand information is included to give breadth and character to the volume, and a practical commercial touch is given by the inclusion of data and drawings from some of the most prominent designers and builders of heat engines in this country. As far as possible elaborate and abstruse methods have been avoided in the derivation of working formulas which have been generally brought to a form capable of direct application.

The book is divided into thirty-five chapters which are grouped in six parts. These cover the heat engine in its various forms, thermodynamics, friction and lubrication, power and thrust, mechanics and machine design. As might naturally be expected the last is the largest of the sections by reason of the great number of engine parts covered, each of which has a separate chapter. In the first part the various forms of heat engine such as the steam engine, the steam turbine and the internal-combustion engine are described. In describing the various types the design and construction are outlined and the text is supplemented by numerous illustrations. Thermodynamics is not treated exhaustively but enough is given to enable the designer to understand the subject generally. The same thing is true of the matter on friction and lubrication, and power and thrust. The mechanics of engine design also receives attention.

MACHINE TOOL OPERATION. By Henry G. Burghardt. Published by the McGraw-Hill Book Co., 239 West Thirty-ninth Street, New York City. Cloth, 4½ by 7⅜ in., 326 pages, 231 illustrations and 23 tables.

The author who is a high school instructor in machine work has prepared this book to assist those who desire to get a knowledge of the principles and elementary operations of the lathe in machine-shop work. The text is the outgrowth of notes which he has prepared in connection with his own teaching work to supplement class talks or demonstrations in the school shop. His aim has been to adapt the text for use in vocational, industrial and trade schools and in apprenticeship courses where training in machine-shop practice is given. With that end in view what the author regards as the necessary elementary information concerning lathe tool operation has been selected and set forth in as clear and simple a manner as possible.

The book is divided into fifteen chapters, some of which comprise a study of operations, while others are intended for study in connection with these operations. After a general discussion of what is a machine shop, what constitutes its equipment and the knowledge which a machinist must possess and his chances for promotion, a general description of lathe construction and operation is given. The third chapter very naturally deals with cutting tools and their speeds, and this is followed by a chapter on the various measuring instruments employed, such as the scale, the caliper, the snap gage and the micrometer. The next eight chapters deal

with various operations performed on the lathe and are in the form of a series of instructions with illustrations to supplement the text. The following three chapters relate to bench work and include a description of the various tools used. Instructions for laying out the work are given in chapter XIII and information on the proper way of performing chipping, filing and scraping operations in chapter XIV. The final chapter is devoted to work at the forge. At the end of each chapter are a number of questions designed to test the student's knowledge of what is given in the chapter.

PRESIDENTIAL ADDRESS OF J. G. VINCENT

(*Concluded from page* 130)

development of airplanes may be considered as divided into two major problems: the powerplant; and the airplane structure, with necessary equipment and instruments. While these two divisions present separate and distinct problems and in most cases can best be handled by engineers having different training and experience, yet they are naturally closely associated. Each group of engineers must have a fair understanding of the possibilities and limitations of the equipment developed by the other group.

In the matter of development and perfection of powerplants for airplanes, I believe that America is second to none except possibly in the case of air-cooled fixed-cylinder radial engines. This situation was, of course, made possible by the war. Our remaining on an equal basis with other powers depends entirely upon whether ways and means shall be found to use sufficient airplane engines in this country to allow engineers and manufacturers to devote enough time and money to the problems involved. I am convinced that we have the talent and facilities in this country to enable us to lead the world in the development and production of airplane engines, if we can make a business out of it, thus getting on a sound financial basis.

In the matter of plane development, I do not feel that we are as far advanced, although we can lay claim to having originated most of the ideas used in airplanes today all over the world. While we have built a few samples of excellent planes, I think that we have not advanced anything like as fast as we should have advanced. Most of the planes in use in this country today were built for the Government for military purposes, and as the Government was endeavoring to cooperate to the fullest extent with our associates in the war, the natural result was that we followed Allied engineering leads. The constant tendency of Allied engineering throughout the war was toward the development of more powerful engines of less weight per horsepower, obtaining increased ability through more power, rather than toward intensive engineering study of plane design to increase efficiency, securing the required performance without the addition of power.

In Germany, probably of necessity, entirely different methods were followed. Engine designs were not changed frequently, nor were excessively large powers attempted. Continued manufacture of the same designs resulted in uninterrupted output and exceedingly reliable engines. Airplane development, on the other hand, advanced by leaps and bounds, with the result that at the time of the Armistice German military airplanes compared very favorably with the best of our available Allied equipment, in spite of the fact that the German machines were equipped with engines weighing from 3 to 3½ lb. per hp. while most of the Allied engines had been improved to the point where their weight was not more than 2 to 2½ lb. per hp.

I understand that since the Armistice German engineers have been going ahead steadily and produced some really wonderful results in all-metal planes, having internally-trussed wings, requiring no struts or wires, thus enormously reducing head resistance. I understand that a plane of this type equipped with a 160-hp. engine weighing over 600 lb. recently carried six passengers at a speed of 120 m. p. h. on a gasoline consumption of 12 gal. per hr., or at the rate of 10 miles to the gallon. I do not know how large it would be practicable to build a plane of this type, but I venture the prediction that the time is not far off when we shall see a plane, equipped with a 180 to 200-hp. engine, capable of carrying ten passengers at a speed of more than 100 m. p. h., with a fuel economy of 8 miles to the gallon or better. Such an airplane would have real commercial possibilities.

This brings me to the message I want to leave with you. This is not and never will be a military nation. Our Congress will never approve a large air force in the regular Army, or large expenditures for aircraft equipment during times of peace. Yet we must be prepared to dominate the air above our country in case of an emergency. This problem must be solved and the S. A. E. should take a leading part in the solution by helping to carry on an educational campaign, as well as doing the necessary engineering work. The Army and the Navy can and are doing much to establish the foundation on which to build. The Post Office Department is doing splendid pioneer work through the agency of the aerial mail. It is to be hoped that the Congress will give these arms of the Government service its continued support.

The only complete answer to the problem, as I see it, however, is to develop commercial aeronautics. It is largely up to us as engineers to bring this about, partly by engineering and partly by united educational work. Many second-hand machines of the Army training type and some new ones of improved types have been sold for commercial purposes during the past year, and these planes are doing splendid missionary work, but we must be prepared to supply greatly improved machines of types suited to various requirements, if we are to take full advantage of our opportunities and thus put the aircraft branch of the automotive industry on a sound transportation basis. The United States positively will *not* be in a safe position until this result has been accomplished.

In closing, I wish to state that my remarks have been prepared with the purpose of directing your thoughts toward the solving of problems which I believe are of importance to us as engineers and citizens. If I have succeeded in my purpose, I am sure that the final result will be along the right line.

PERSONAL NOTES OF THE MEMBERS

D. M. Ackerlind has accepted a position as checker and layout draftsman with the Trego Automotive Corporation, New Haven, Conn. He was formerly designer with the Nordyke & Marmon Co., Indianapolis.

H. W. Adams, formerly instructor of automotive gas tractor engineering in the City High Schools, Minneapolis, has accepted the position of superintendent of the Minneapolis Auto and Tractor School of that city.

Emil L. Apor has accepted a position in the experimental department of Fairbanks, Morse & Co., Beloit, Wis. He was formerly a student at Purdue University, West Lafayette, Ind.

Walter J. Baumgartner, who was formerly chief engineer and general superintendent of the Duplex Engine Governor Co., Brooklyn, N. Y., has accepted a position as engineer with the Garford Motor Truck Co., Lima, Ohio.

Norman Bell has been appointed assistant sales manager for the Norma Co. of America, Long Island City, N. Y. He has been connected with the company for over three years as sales engineer.

Albert C. Bergmann has accepted a position as general sales manager of the Sterling Motor Truck Co. of New York, Inc., 132nd Street and Twelfth Avenue, New York City. He was formerly New York branch manager of the Standard Parts Co., Cleveland.

Aldrick A. Bertrand, formerly general superintendent of the Chalkis Mfg. Co., Detroit, has accepted the position of supervisor of tools and equipment with the Cutler-Hammer Mfg. Co., Milwaukee.

G. W. Beyerle has accepted a position as engineer with the Wadsworth Sand Cutter Corporation, 8610 Hough Avenue, Cleveland. He was formerly a consulting engineer at Independence, Ohio.

Alf C. Boock has severed his connection with the Pan Motor Co., St. Cloud, Minn., and accepted a position as layout draftsman with the Waterloo Gasoline Engine Co, Waterloo, Iowa.

Otto Bruenauer has been elected vice-president and made general manager of the Chicago Standard Axle Co., 1300 Fletcher Street, Chicago. He was formerly vice-president of sales of the American Truck Co., also of that city.

H. L. Butterworth is no longer assistant in the experimental laboratory of the Nordyke & Marmon Co., Indianapolis, but is affiliated with the Alena Steam Products Co., also of that city.

Ralph E. Cherry has accepted a position as engineer in the truck department of the Parrett Tractor Co., Chicago Heights, Ill. He was formerly chassis engineer with the Standard Steel Car Co., Pittsburgh.

Fred A. Clock has resigned as chief engineer of the Watson Products Corporation, Canastota, N. Y., to accept the position of chief engineer with the Capitol Motors Corporation, Fall River, Mass.

David F. Crawford, formerly designing engineer, with the Midwest Engine Co., Indianapolis, has accepted the position of sales engineer with the Hyatt Roller Bearing Co., 2715 South Michigan Avenue, Chicago.

H. I. Crow, formerly aeronautical mechanical engineer in the production engineering department, Bureau of Aircraft Production, Dayton, Ohio, has accepted a position with the Fageol Motors Co., Oakland, Cal., in its plant at 1827 East Eighty-ninth Street, Cleveland.

Bruno Dahl has accepted a position as mechanical engineer with Abo Yern Manufaktur, Abo, Finland. He was formerly engineer in the automotive department of the Standard Steel Car Co., Pittsburgh.

Charles S. Dahlquist has resigned as chief engineer of the Timken-Detroit Axle Co., Detroit, to accept the position of director of engineering with the Eaton Axle Co., Cleveland.

Stephen O. DeOrlow, formerly designing engineer in the research laboratory of the General Motors Corporation, Detroit, has been appointed field representative of the General Motors Export Co., 1764 Broadway, New York City.

W. H. Diefendorf has severed his connection with the Weekes-Hoffman Co., Syracuse, N. Y., and is now president and treasurer of the Diefendorf Gear Corporation, also of that city.

John W. Dissette has been elected president and treasurer of the Sure Spark Ignition Corporation, Washington. He was formerly chief of the aircraft section in the office of the Director of Sales, also in that city.

Frederick S. Duesenberg, who since the dissolution of the Duesenberg Motors Corporation, Elizabeth, N. J., has been designing internal-combustion engines, has been appointed chief engineer of the Duesenberg Automobile & Motor Corporation, Indianapolis.

Wayne E. Dunston has accepted the position of factory manager and chief engineer of the Kalamazoo Spring & Axle Co., Kalamazoo, Mich. He was formerly manager of the Crown Hardware Mfg. Co., Dayton, Ohio.

C. M. Eason has been elected vice-president of the Hyatt Roller Bearing Division of the General Motors Corporation, Newark, N. J. He was formerly general manager of the Engineering Development Co., Moline, Ill.

D. C. Fleming, formerly assistant inspector of ordnance materials and motor vehicles with the Holt Mfg. Co., Peoria, Ill., has become assistant director in the department of technical instruction of the United Y. M. C. A., 347 Madison Avenue, New York City.

Brilsford P. Flint has resigned his position of superintendent of the Yuba Mfg. Co., Benicia, Cal., and has accepted a similar position with the United States Fiber Products Co., 210 Capital National Bank Building, Sacramento, Cal.

E. S. Foljambe, formerly directing editor of the Chilton Publications, Philadelphia, has accepted a position with the Goodyear Tire & Rubber Co. of California, Los Angeles.

Clarence M. Foss has received his discharge from the Army where he held the rank of major in the Ordnance Department at Washington.

F. C. Goldsmith has resigned as chief engineer of the New Departure Mfg. Co., Bristol, Conn., and became affiliated with the Willys-Overland Corporation, New York City, on July 1.

William Harrower, formerly chief engineer of the Collins Motors, Inc., Huntington, N. Y., has accepted a position with the Everlasting Valve Co., 65 Fisk Street, Jersey City, N. J.

Frank A. Hayes has accepted the position of chief engineer with the Owen Magnetic Motor Car Corporation, Wilkes-Barre, Pa. He formerly held a similar position with the International Fabricating Corporation also of that city.

E. V. Higbee has joined the production department of the Stanley Works, New Britain, Conn. He was formerly assistant research engineer with the Locomobile Co. of America, Bridgeport, Conn.

E. K. Hill has severed his connection with the E. J. Longyear Co., Marquette, Mich., and has accepted the position of layout draftsman and detailer on heavy oil engines with Fairbanks, Morse & Co., Beloit, Wis.

A. L. Houmer has accepted a position as sales manager with Miguel Mateu, 31 Place St. Ferdinand, Paris, France. For a short time he was sales engineer with Bergerat & Co., 10 Rue de Seze, Paris.

Clarence F. Jamison, formerly assistant general manager of the Elgin Motor Car Corporation, Argo, Ill., has accepted a position with the Comet Automobile Co., Decatur, Ill.

Fred J. Johnson has resigned his position as tractor designer with the Gray Tractor Co., Minneapolis, and has accepted a position as tractor and jig designer with the Crown Iron Works Co., also of that city.

R. L. Johnston, formerly chief metallurgical engineer of the Exeter Machine Works, Pittston, Pa., has accepted a position with the American Non-Ferrous Metals Corporation, 713 Crozer Building, Chester, Pa.

Charles G. King has returned from England and accepted the position of manager of the Miles Piston Ring Sales Co., 90 Mason Street, Milwaukee.

Luther J. Kinnard has accepted a position as engineering inspector attached to the Chicago office of the Cutler-Hammer Mfg. Co., Milwaukee. He formerly attended Purdue University, Lafayette, Ind.

Harry E. Lambert has accepted a position as tractor engineer of the McDougall-Duluth Co., Duluth, Minn. He was formerly chief draftsman of the tractor department of the Pan Motor Co., St. Cloud, Minn.

Henry M. Leland, president of the Lincoln Motor Co., Detroit, received the degree of doctor of engineering at the recent commencement of the University of Michigan.

Walter O. Lum, president of the Gould Motor Parts Co., York, Pa., has also been made general manager of the New Era Mfg. Co., 2033 Fifth Avenue, New York City.

Robert F. McCann, formerly manager for the Refiners Oil Co., Dayton, Ohio, has accepted a position with the Dayton Automotive Sales Co., also of that city.

W. C. McCormick has been elected president and general manager of the newly incorporated McCormick Motor Car Co., Williamsport, Pa., which has been formed to take over the business formerly conducted under his own name.

Arthur I. Marcum, formerly draftsman with the Holt Mfg. Co., Stockton, Cal., has accepted a position as draftsman with the Fageol Motors Co., Oakland, Cal.

Willard S. Mears has been elected vice-president and treasurer of the Enameling & Stamping Corporation, Long Island City, N. Y. He was formerly general manager and vice-president of the Oneida Motor Truck Co. of New York, New York City.

Thomas T. O'Brien, manager of the truck department of the Olds Motor Works, Lansing, Mich., is now in charge of all sales promotion work including the advertising department.

William O. Olson has severed his connection with the Arc'O Mfg. Co., Chicago, and is now designing production engineer for the William O. Olson Co., 431 South Dearborn Street, Chicago, of which he is one of the organizers.

Ernesto Ornelas, having been graduated from the Colorado School of Mines, Golden, Col., is now secretary and engineer of the Cia. Minera de San Juan S. A., Apartado Postal 21, Chihuahua, Mexico.

Harry A. Oswald has accepted a position with the Hamilton Motors Co., Grand Haven, Mich. He was formerly chief engineer of the Quaker City Corporation, Philadelphia.

G. R. Petri has severed his connection with the Newport News Shipbuilding & Dry Dock Co., Newport News, Va., and has accepted a position with the Reynolds Truck Sales Co., Detroit.

W. F. Pfander, formerly chief engineer of the Allen Motor Co., Fostoria, Ohio, has accepted a position with the Chevrolet Motor Co., New York City.

B. G. Prytz has resigned as president of the S. K. F. Industries, Inc., New York City, and has been elected managing director of the Aktiebolaget Svenska Kullagerfabriken, the parent company, with headquarters at Gothenburg, Sweden.

Karl F. Ranger has accepted a position as tool engineer with Morgan & Wright, Detroit, Mich. He was formerly head checker in the tool design department of the Kohler Co., Kohler, Wis.

Balfour Read, formerly of Marion, Ind., has accepted a position as assistant chief engineer of the Barley Motor Car Co., Kalamazoo, Mich.

W. C. Rosenthal has accepted a position with the Aladdin Products Co., 312 North May Street, Chicago. He was formerly in the engineering department of the Packard Motor Car Co., Detroit.

Walter H. Sammis, formerly an instructor in the electrical engineering department of Columbia University, New York City, has accepted a position in the electrical engineering department of the Consumers Power Co., 224 West Main Street, Jackson, Mich.

R. H. Sanders has severed his connection with the Raymond Engineering Corporation, New York City, and accepted a position as engine designer with the New York Rotary Motor Co., 25 West Forty-fifth Street, also of that city.

George William Sargent has severed his connection with the Crucible Steel Co. of America, Pittsburgh, where he held the office of vice-president and metallurgist. He is now devoting his entire attention to the Molybdenum Corporation of America, 212 Empire Building, Pittsburgh, of which he is president. He holds the same office in the Electric Reduction Co., an affiliated organization.

John V. Schafer has accepted a position as engineer with Fairbanks, Morse & Co., Beloit, Wis. He was formerly assistant engineer with the Caskey-Dupree Mfg. Co., Marietta, Ohio.

George L. Sexton, formerly connected with the Sexton Agricultural Tractor, Detroit, is now a designer with Sexton & Long, 56 bis Rue De Chateudun, Paris.

B. Russell Shaw, who was formerly general manager of the Aeronautical Instrument Co., New York City, is now connected with the Lawson Airplane Co., Milwaukee.

Ralph H. Sherry has resigned as metallurgist of the General Motors Corporation, Detroit, and has accepted the position of metallurgist for the Willys Corporation, Elizabeth, N. J.

G. F. Shillinger, formerly electrical and mechanical engineer with the Michigan State Auto School, Inc., Detroit, has accepted the position of engineer in the manufacturers' service division of the Vacuum Oil Co., 214 New Telegraph Building, Detroit.

Charles R. Short has accepted the position of engineer with the Dayton-Wright Division of the General Motors Corporation, Dayton, Ohio. He was formerly chief engineer of the Northway Motor & Mfg. Co., Detroit.

Sydney C. Smith will sail shortly from New York City for India, where he will have charge of service work for the Packard Motor Car Co. He will make his headquarters at Delhi.

William S. Stockton has resigned as assistant chief engineer of the New Departure Mfg. Co., Bristol, Conn., to accept a position with the Willys Corporation, Elizabeth, N. J.

Herman Theuman has been made president and engineer of the Theuman Engineering Co., 405 Commercial Building, Louisville Ky.

F. W. Trabold has recently been made general sales manager of J. H. Williams & Co., Brooklyn, N. Y. He formerly held the office of vice-president and general manager in the same company.

James R. Van Dyke, teacher in the mathematics department of the Medford High School, Medford, Ore., has accepted a position as designing engineer with Fairbanks, Morse & Co., Three Rivers, Mich.

Herbert B. Van Pelt, formerly vice-president and manager of sales of the Pittsburgh Shafting Co. of Detroit, has organized the Service Steel Co., also of that city, to market seamless and welded steel tubing.

A. B. Webb has accepted a position as chief engineer of General Tractors, Inc., 675 Old Colony Building, Chicago. He was formerly chief engineer of the Monarch Tractor Co., Watertown, Wis.

A. Raymond White, formerly designing engineer in the engine department of the Curtiss Engineering Corporation, Garden City, N. Y., has become an engine designer in the ordnance engineering laboratory of the Holt Mfg. Co., Peoria, Ill.

E. Field White, formerly chief efficiency mechanical engineer of the Dort Motor Car Co., Flint, Mich., has accepted the position of chief of plant engineering with the Hudson Motor Car Co., Detroit.

Stanley H. Whiting, having been graduated from the Tri-State College of Engineering, Angola, Ind., as a mechanical engineer, has accepted a position as layout man and designer with the Northway Motor & Mfg. Co., Detroit.

T. C. Whisler, formerly of Lima, Ohio, has accepted a position as draftsman with the Moline Plow Co., Rock Island, Ill.

William Wolfred has accepted the position of plant manager of the Bahmann Iron Works Co., Dayton, Ohio. He was formerly works manager of the Pawling & Harnischfeger Co., Milwaukee.

Alvin M. Yocom has severed his connection with the Bethlehem Motors Corporation, Bethlehem, Pa., as chief draftsman, to accept the position of chief engineer with the United States Axle Co., Pottstown, Pa.

Applicants *for* Membership

The applications for membership received between May 26 and June 14, 1920, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

AUSTIN, SYDNEY BERTRAND, inspection engineer, Eisemann Magneto Corporation, *Brooklyn, N. Y.*

BARNES, NEWELL H., cost accountant, Cushman Motor Works, *Lincoln, Neb.*

BARTLETT, PERCY H., chief tester, Diamond T Motor Car Co., *Chicago, Ill.*

BARUTH, CARL WILLIAM, draftsman, General Motors Corporation, *Detroit.*

BLOOM, EDGAR G., Bloom Flusher Co., *Tiffin, Ohio.*

BROWNYER, NELSON R., draftsman, Paige Motor Car Co., *Detroit.*

BURLEY, E. R., JR., chief engineer, Available Truck Co., *Chicago.*

CHAMPION, PROSPER, sales engineer, Champion Ignition Co., *Flint, Mich.*

CREAMER, JOHN F., manufacturers' representative, Firestone Steel Products Co., *Akron, Ohio.*

DEMORE, L. A., chief engineer, Mercury Mfg. Co., *Chicago.*

DIESZ, EDWARD H., assistant chief draftsman, International Harvester Co., *Akron, Ohio.*

DRESSER, DANIEL R., testing engineer, International Motor Co., *New York City.*

EVERETT, WILLIAM T., superintendent, Westinghouse Electric & Mfg. Co., *East Pittsburgh, Pa.*

FLYNN, F. K., chief engineer, Luce Sugar Cane Harvester Co., *Watertown, Wis.*

GARGIULO, SALVATORE, master mechanic, G. & O. Mfg. Co., *New Haven, Conn.*

GOCHNAUER, G. C., president, Belmont Motors Corporation, *Harrisburg, Pa.*

GRASETT, D. BLIGHT, sales manager, automobile division, Crane Packing Co., *Chicago.*

GRIFFITH, R. R., mechanical engineer, University of Minnesota, *Minneapolis.*

HACKETT, FRANK D., chief engineer, Air Service Flying School, Rockwell Field, *Coronado, Cal.*

HALL, LOUIS B., body engineer, International Motor Co., *New York City.*

HARRINGTON, C. G., chief draftsman, Gardner Motor Co., *St. Louis.*

HARRINGTON, W. H., engineer, New Departure Mfg. Co., *Bristol, Conn.*

HEITBRINK, J. HENRY, purchasing agent, Morris Machine Tool Co., *Cincinnati.*

HOWATT, GERALD, national service manager, Willard Storage Battery Co., *Cleveland.*

HUTCHINSON, THOMAS MASSIE, chief inspector of motor transport, Royal Army Service Corps, *London, England.*

JOHNSON, HARRY HERMAN, mechanical draftsman, Class Journal Co., *New York City.*

JOHNSON, HOWARD M., transportation engineer, Harold L. Arnold, *Los Angeles, Cal.*

KELLY, GEORGE B., draftsman, Acme Motor Truck Co., *Cadillac, Mich.*

KINDL, CARL H., designing engineer, Westinghouse Electric & Mfg. Co., *East Pittsburgh, Pa.*

KOELLNER, LOUIE F., layout draftsman, Dorris Motor Car Co., *St. Louis.*

KOHR, ROBERT F., assistant mechanical engineer, Bureau of Standards, *Washington.*

LANNING, JOHN G., assistant vice-president, Detroit Lubricator Co., *Detroit.*

LIBBEY, WILBUR F., salesman, Doehler Die-Casting Co., *Chicago.*

LIVERMORE, WILLIAM T., draftsman, International Motor Co., *New York City.*

LOTZ, WALTER P., tool supervisor, International Motor Co., *New Brunswick, N. J.*

MCKAY, DONALD GEORGE, mechanical designer, Lincoln Motor Co., *Detroit.*

MARTIN, WILBUR A., design engineer in charge of layout, Glenn L. Martin Co., *Cleveland.*

MEDWEDEFF, MARSHALL H., metallurgical engineer, Samson Tractor Co., *Janesville, Wis.*

MIDDLETON, W. IRVING, electrical engineer, Simplex Wire & Cable Co., *Boston.*

MOHL, DONALD J., draftsman, Acme Motor Truck Co., *Cadillac, Mich.*

MORRIS, A. C., draftsman, Service Motor Truck Co., *Wabash, Ind.*

MORTON, W. D., vice-president and general manager, Meteor Motors, Inc., *Philadelphia.*

NEILL, GEORGE G., assistant mechanical engineer, material section, Air Service, *Washington.*

NELSON, ARNE T., master mechanic, Anderson Electric Car Co., *Detroit.*

OVERSMITH, RALPH E., chief engineer, Buffalo Truck & Tractor Corporation, *Buffalo.*

PARKS, GALE D., draftsman, Gramm-Bernstein Motor Truck Co., *Lima, Ohio.*

PERIN, DONALD W., president, Perin Automotive Engineering Co., *Boston.*

PFEIFFER, CLARENCE L., body engineer, William Pfeiffer Auto & Carriage Works, *Omaha, Neb.*

PFEIFFER, JOHN E., mechanical and automotive engineer, *Chicago.*

PRESTON, L. H., chief inspector, Falls Motors Corporation, *Sheboygan Falls, Wis.*

REICH, JOHN CARL, superintendent, Firestone Tire & Rubber Co., *Akron, Ohio.*

ROBERT, HARRY E., assistant to production and inspection manager, Timken-Detroit Axle Co., *Chicago.*

ROE, WALTER H., consulting mechanical engineer, Spayth Block, *Tiffin, Ohio.*

ROSSMASSLER, CARL, designer, Domestic Engine & Pump Co., *Shippensburg, Pa.*

SEAVERNS, BYRON H., designer, Service Motor Truck Co., *Wabash, Ind.*

SHAW, A. D., sales engineer, S.K.F. Industries, *Philadelphia.*

SHEFFIELD, E. A., salesman, Eclipse Co., *Indianapolis.*

SHERIDAN, HENRY K., research engineer, Ordnance Department, *Peoria, Ill.*

SMALL, B. C., service data, Diamond T Motor Car Co., *Chicago.*

SOHN, MILTON C., mechanical draftsman, Holt Mfg. Co., *Stockton, Cal.*

STORTZ, ROBERT, assistant to chief engineer, Nash Motors Co., *Kenosha, Wis.*

THORNE, MAURICE A., assistant physicist, Bureau of Standards, *Washington.*

THWEATT, CARROLL P., assistant inspection engineer, Eisemann Magneto Corporation, *Brooklyn, N. Y.*

TONER, A. W., research engineer, Ford Motor Car Co., *Highland Park, Mich.*

WADE, JUNIUS S., mechanical engineer, Wade & Wait, *Augusta, Ark.*

WAGNER, LEONARD J., draftsman, Standard Parts Co., *Cleveland.*

WALKER, R. L., production manager, Sewell Cushion Wheel Co., *Detroit.*

WRAY, HERBERT L., factory manager, Standard Separator Co., *Milwaukee.*

YANSS, GEORGE W., in charge of engineering, Spicer Mfg. Corporation, *Pottstown, Pa.*

YOUNG, FRED C., assistant metallurgist and chemist, Ford Motor Car Co., *Highland Park, Mich.*

ZICKEL, ABRAHAM, steel specification work, Willys Corporation, *Elizabeth, N. J.*

Applicants *Qualified*

The following applicants have qualified for admission to the Society between June 10 and July 10, 1920. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (E S) Enrolled Student; (S M) Service Member; (F M) Foreign Member.

AMBROSE, FREDERICK S. (M) chief engineer, Singer Motor Co., Inc., North Third Avenue, *Mount Vernon, N. Y.*

BEARD, H. P. (A) salesman, Ericsson Mfg. Co., 918 Century Building, Chicago, (mail) 321 Hamilton Street, *Evanston, Ill.*

BENTLEY, G. P. (M) layout draftsman, Supreme Motors Corporation, *Warren, Ohio,* (mail) 240 Scott Street.

CAST, J. F. (A) assistant manufacturers' sales manager, Firestone Tire & Rubber Co., Akron, Ohio, (mail) 1841 Rosemont Road, *East Cleveland, Ohio.*

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CLAWSON, FREDERICK A. (A) salesman, Ericsson Mfg. Co., 918 Century Building, *Chicago.*

COX, CLYDE CURTIS (M) 218 Oakridge Drive, *Jackson, Mich.*

CROMWELL, J. C. (M) engineer, Cromwell Steel Co., Sincere Building, *Cleveland.*

DISSETTE, JOHN W. (M) Sure Spark Ignition Corporation, 1512 H Street, Northwest, *Washington.*

DOWNS, CYRIL WINFRED (J) inspection department, Standard Parts Co., *Cleveland,* (mail) 1363 West Eightieth Street.

GOLDSMITH, HENRY (A) branch sales manager, G & O Mfg. Co., New Haven, Conn., (mail) 828 North Broad Street, *Philadelphia.*

GORHAM, WILLIAM R. (M) mechanical engineer, Central Motor Mfg. Co., Tokyo, Japan, (mail) Gorham Engineering Co., 127 Mission Street, *San Francisco.*

HAYNES, ROBERT B. (J.) engine designer, LaFayette Motors Co., *Indianapolis,* (mail) 327 Villa Avenue.

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MAAS, FRANK W. (A) advertising manager and vice-president, *Tractor and Implement Topics,* New York City, (mail) 1105 Mallers Building, *Chicago.*

MAHOUX, GEORGES (F M) ingenieur, chef des services techniques, 66 Rue Colbert, *Colombes (Seine) France.*

MEYER, J. F. (M) chief engineer, McFarlan Motor Co., *Connersville, Ind.*

ORR, WILLIAM A. C. (A) draftsman, engineering department, City of Winnipeg, *Winnipeg, Man., Canada,* (mail) 32 Knappen Avenue.

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TYKEN, JOHN G. H. (A) assistant chief draftsman, Fageol Motors Co., *Oakland, Cal.,* (mail) 7420 Lockwood Street.

VOSLER, KENNETH D. (J) chief draftsman, Aeromarine Plane & Motor Co., Keyport, N. J., (mail) 314 South Feltus Street, *South Amboy, N. J.*

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WARNER, GEORGE C. (A) sales engineer, Gurney Ball Bearing Co., Jamestown, N. Y., (mail) 20 East Jackson Boulevard, *Chicago.*

WESTLING, CARL J. (J) designer, Austin Machinery Corporation, *Muskegon, Mich.*